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TRANSACTIONS

OF THE

Illinois State Academy of Science

SEVENTEENTH ANNUAL MEETING

Elgin High School and Elgin Academy

May 1, 2 and 3, 1924

VOLUME XVII

Edited by C. F. Phipps, *Secretary*

OHIO STATE UNIVERSITY

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A. R. Crook, *Librarian.*

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OFFICERS AND COMMITTEES FOR 1924-25.

President, W. G. BAIN, St. John's Hospital, Springfield.
1st Vice-President, C. H. SMITH, Hyde Park High School, Chicago.
2nd Vice-President, R. C. LANPHIER, Sangamo Electric Co., Springfield.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, W. B. MCDOUGALL, University of Illinois, Urbana.
Librarian, A. R. CROOK, State Museum, Springfield.

The Council.

The Council is composed of the above officers and the last two retiring presidents.

Committee on Membership.

B. K. RICHARDSON, Dept. of Public Health, Springfield, Chairman.
W. H. PACKARD, Bradley Polytechnic Institute, Peoria.
J. H. BRETZ, University of Chicago, Chicago
T. E. SAVAGE, University of Illinois, Urbana.
ALICE J. PATTERSON, State Normal University, Normal.

Committee on Affiliation.

W. S. BAYLEY, University of Illinois, Urbana, Chairman.
MRS. ELEANOR C. SMITH, 104 Winsted Ave., Joliet.
M. M. LEIGHTON, Illinois Geological Survey Division, Urbana.
W. G. WATERMAN, Northwestern University, Evanston.
C. A. SHULL, University of Chicago, Chicago.

Committee on Ecological Survey.

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GEORGE D. FULLER, University of Chicago, Chicago.
V. E. SHELFORD, University of Illinois, Urbana.
W. B. MCDOUGALL, University of Illinois, Urbana.
R. B. MILLER, State Natural History Survey, Urbana.
H. S. PEPOON, Lake View High School, Chicago.
RUTH MARSHALL, Rockford College, Rockford.
A. O. WEESE, James Millikin University, Decatur.
M. M. LEIGHTON, Illinois Geological Survey Division, Urbana.
CLARENCE BONNELL, Township High School, Harrisburg.
MARY STEAGALL, State Normal University, Carbondale.

Committee on High School Science and Clubs.

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F. C. BOHANNAN, Galesburg High School, Galesburg.
C. M. TURTON, 2055 E. 72nd Place, Chicago.

Committee on Conservation.

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M. M. LEIGHTON, Illinois Geological Survey Division, Urbana.
W. N. CLUTE, Editor "American Botanist," Joliet.

Committee on Legislation and Finance.

DR. DON W. DEAL, Leland Office Building, Springfield, Chairman.
EDWARD W. PAYNE, First State Trust and Savings Bank, Springfield.
CLARENCE BONNELL, Township High School, Harrisburg.
J. C. HESSLER, Knox College, Galesburg.
U. S. GRANT, Northwestern University, Evanston.

Committee on Publications.

THE PRESIDENT.
THE SECRETARY.
L. E. HILDEBRAND, New Trier Township High School, Kenilworth.

Delegates to Represent the Academy on the Conservation Council of Chicago.

H. C. COWLES, University of Chicago, Chicago.
W. G. WATERMAN, Northwestern University, Evanston.

PAST OFFICERS OF ILLINOIS STATE ACADEMY.

1907

(Organization meeting, Dec. 7, 1907, Springfield.)

Chairman, U. S. GRANT, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.

1908

(First annual meeting, Decatur, Feb. 22, 23, 1908.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1909

(Second annual meeting, Springfield, Feb. 20, 1909.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1910

(Third annual meeting, Urbana, Feb. 18, 19, 1910.)

President, S. A. FORBES, University of Illinois.
Vice-President, JOHN M. COULTER, University of Chicago.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1911

(Fourth annual meeting, Chicago, Feb. 17, 18, 1911.)

President, JOHN M. COULTER, University of Chicago.
Vice-President, R. O. GRAHAM, Illinois Wesleyan University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1912

(Fifth annual meeting, Bloomington, Feb. 23, 24, 1912.)

President, W. A. NOYES, University of Illinois.
Vice-President, J. C. UDDEN, University of Texas.
Secretary, FRANK C. BAKER, Chicago Academy of Science.
Treasurer, J. C. HESSLER, James Millikin University.

1913

(Sixth annual meeting, Peoria, Feb. 21, 22, 1913.)

President, HENRY CREW, Northwestern University.
Vice-President, A. R. CROOK, State Museum, Springfield.
Secretary, OTIS W. CALDWELL, University of Chicago.
Treasurer, J. C. HESSLER, James Millikin University.

PAST OFFICERS OF THE ACADEMY—Continued

1914

(Seventh annual meeting, Evanston, Feb. 20, 21, 1914.)

President, FRANK W. DEWOLF, State Geological Survey.
Vice-President, H. S. PEPOON, Lake View High School, Chicago.
Secretary, E. N. TRANSEAU, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1915

(Eighth annual meeting, Springfield, Feb. 19, 20, 1915.)

President, A. R. CROOK, State Museum, Springfield.
Vice-President, U. S. GRANT, Northwestern University.
Secretary, E. N. TRANSEAU, Eastern State Normal School, Charleston.
Treasurer, J. C. HESSLER, James Millikin University.

1916

(Ninth annual meeting, Urbana, Feb. 18, 19, 1916.)

President, U. S. GRANT, Northwestern University.
Vice-President, E. W. WASHBURN, University of Illinois.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.

1917

(Tenth annual meeting, Galesburg, Feb. 23, 24, 1917.)

President, WILLIAM TRELEASE, University of Illinois.
Vice-President, H. E. GRIFFITH, Knox College, Galesburg.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, H. S. PEPOON, Lake View High School, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

1918

(Eleventh annual meeting, Joliet, Feb. 22, 23, 1918.)

President, J. C. HESSLER, James Millikin University.
Vice-President, JAMES H. FERRISS, Joliet.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1919

(Twelfth annual meeting, Jacksonville, March 21, 22, 1919.)

President, R. D. SALISBURY, University of Chicago.
Vice-President, ISABEL S. SMITH, Illinois College, Jacksonville.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, T. L. HANKINSON, State Normal School, Charleston.
Librarian, A. R. CROOK, State Museum, Springfield.

1920

(Thirteenth annual meeting, Danville, Feb. 20, 21, 1920.)

President, HENRY B. WARD, University of Illinois.
Vice-President, GEO. D. FULLER, University of Chicago.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University.
Librarian, A. R. CROOK, State Museum, Springfield.

PAST OFFICERS OF THE ACADEMY—Concluded

1921

(Fourteenth annual meeting, Carbondale, April 29, 30, 1921.)

President, HENRY C. COWLES, University of Chicago.
Vice-President, CHAS. T. KNIPP, University of Illinois.
Secretary, J. L. PRICER, State Normal University, Normal.
Treasurer, W. G. WATERMAN, Northwestern University.
Librarian, A. R. CROOK, State Museum, Springfield.

1922

(Fifteenth annual meeting, Rockford, April 27, 28, 29, 1922.)

President, CHAS. T. KNIPP, University of Illinois.
Vice-President, MISS RUTH MARSHALL, Rockford College, Rockford.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1923

(Sixteenth annual meeting, Galesburg, May 3, 4, 5, 1923.)

President, W. S. BAYLEY, University of Illinois.
Vice-President, W. G. WATERMAN, Northwestern University.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

1924

(Seventeenth annual meeting, Elgin, May 1, 2, 3, 1924.)

President, W. G. WATERMAN, Northwestern University.
Vice-President, H. J. VANCLEAVE, University of Illinois.
Secretary, C. FRANK PHIPPS, State Teachers College, DeKalb.
Treasurer, WM. F. SCHULZ, University of Illinois.
Librarian, A. R. CROOK, State Museum, Springfield.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary

State Teachers College, DeKalb, Illinois

Council Meeting, Urbana, May 19, 1923

President Waterman presided and all six members of the Council were present.

Invitations from Elgin, Decatur, Normal and Bloomington, and Joliet, urging the Academy to hold its next annual meeting in their respective cities, were read, and after thorough discussion it was voted to accept the Elgin invitation. The decision was based on two facts; first, that the Academy has never met in Elgin while it has met in the other cities named; and second, Elgin had extended a cordial invitation a year ago to hold our 1923 meeting there.

The following standing committees were appointed: Committee on Ecological Survey, H. C. Cowles, Chairman, George D. Fuller, Ruth Marshall, V. E. Shelford, W. B. McDougall, R. B. Miller, A. O. Weese, James H. Ferriss, H. S. Pepoon and M. M. Leighton.

Committee on High School Science and Clubs: John C. Hessler, Chairman, F. H. Colyer, C. M. Turton, Harriet Strong, W. S. Bayley, F. C. Bohannan, R. G. Buzzard, F. D. Townsley and H. H. Radcliffe. Chairman Hessler was authorized to add another member to the Committee and to make other changes if desired.

By vote the Committee on High School Science and Clubs was empowered to use funds up to $50. if necessary, to carry on its work.

The President was given authority to have printed a small four page pamphlet, setting forth useful information concerning the Academy and its work, for distribution among members and for use in securing new members; the cost of such a pamphlet not to exceed $30.

The following amendments and additions to the constitution were presented to be acted upon at the next annual meeting:

Article V.—Council. The first sentence to read: The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, and the presidents of the two preceding terms. (This allows for two past-presidents on the Council instead of one.)

Addition to Article V.—At the annual meetings the presiding officers of all the affiliated scientific societies of the state shall meet with the Academy Council for the discussion of policies.

Article VI.—Standing Committees. Add to this article a Committee on Affiliation. Also add to this article,—The Committee on Affiliation shall consist of five members, chosen annually by the Academy.

By vote the President was empowered to appoint a temporary committee on Affiliation to serve this year and work among the County Academies and other scientific societies of the state, with a view to securing the affiliation of their members with the Academy, so that all may cooperate in the interest of science.

The following Committee on Affiliation was appointed: W. S. Bayley, Chairman, H. J. VanCleave, F. R. Jelliff, Clarence Bonnell and W. G. Waterman.

Council Meeting, Urbana, November 17, 1923

President Waterman presided at the meeting. All six members of the Council were present.

Treasurer Schulz presented four names for membership. It was voted that the names be accepted by the Council and presented at the annual meeting of the Academy.

By vote the Secretary was instructed to invite the Illinois Division of the Mathematical Association to meet again with the Academy at the next annual meeting.

The date of the annual meeting to be held at Elgin was set for May 1, 2, and 3, 1924. However, the President was empowered to change the date to a week earlier or later, if it was found that these dates conflicted with some other large meeting of a scientific nature.

The Treasurer submitted the following report:

Balance on hand May 1, 1923	$459.97
Receipts from May 1 to Nov. 17	392.30
	852.27
Expenditures, May 1 to Nov. 17	294.30
	$557.97

Dr. Bayley reported progress for his Committee on Affiliation of local scientific societies.

It was voted that the following plan concerning the affiliation of local scientific societies should be recommended to the Academy at the annual meeting:

Affiliated Societies

Local Academies of Science and similar Scientific Societies in the State, other than High School Science Clubs, may become affiliated with the State Academy by an affirmative vote of three-fourths of the members of such society, when confirmed by vote of the members of the State Academy at their annual meeting.

Members of such affiliated societies may become members also of the State Academy without initiation fee, by paying annual dues to the treasurer of the local society sufficiently large so that the local treasurer may send to the treasurer of the State Academy one dollar for each member, except for life members of the State Academy, or for those who are also members of the A. A. A. S.

The Secretary presented a communication inviting our Academy to send a delegate to a commemorative meeting to be held in Philadelphia, December 6, 1923, in honor of the centenary of the birth of Joseph Leidy, one of America's greatest naturalists.

The Secretary was authorized to appoint as our delegate to the above meeting some Academy member residing in or near Philadelphia.

By vote the President was empowered to appoint a Program Committee for the annual meeting, to consist of the President, Secretary and one or more other members. This committee is to have charge of the selection of papers to be read at the annual meeting, and to plan other features for the program.

It was voted to present the following amendments of the constitution at the annual meeting for action:

Article IV.—After the word president, substitute for vice-president,—a first vice-president, a second vice-president.

This provides for an additional officer, a second vice-president.

Also add to Article IV. the following: The second vice-president shall be a resident of the town in which the next annual meeting is to be held, and shall be appointed by the Council as soon as the next meeting place has been decided upon.

Council Meeting, Elgin High School, May 1, 1924

The Council met with the Local Committee of Arrangements at the High School Building, Elgin.

Final arrangements for the Annual Meeting were discussed and all plans completed.

New names were presented for membership. The list of names was approved by the Council, and it was voted to recommend the Treasurer's list of new members to the Academy for election.

A letter from the British Association of Science was read, in which an invitation was extended to our Academy of Science to attend the Science Convention to be held in Toronto, August 6-13, 1924. It was recommended that the incoming Council appoint delegates to the Toronto Convention from among those members of our Academy who were planning to attend.

Annual Business Meeting, Elgin High School, May 2, 1924, 8:45 A. M.

President W. G. Waterman presided, and, after calling the meeting to order gave a brief report concerning the printing and distributing of the leaflets on the work and aims of the Academy. A copy of the leaflet had been sent out previously to each member of the Academy.

The Treasurer submitted the following report:

REPORT OF THE TREASURER FOR THE YEAR 1923-1924.

RECEIPTS.

Balance on hand, May 1st, 1923	$459.97
From Local Dues	130.00
From National Dues	332.50
For Reprints	176.61
For Transactions	21.00
Total	$1,120.08

DISBURSEMENTS.

Reprints, Printing Bill		$156.20
Collected for A. A. A. S		32.00
Refund Dues		13.00
Expense of President's Office		56.35
Expenses of Secretary's Office		351.26
Expenses of Treasurer's Office		48.74
Secretary's Salary		150.00
Total		$807.55
Total Receipts	$1,120.08	
Total Expense	807.55	
Balance on hand	$312.53	

The report was accepted by vote and referred to the auditing committee.

The Membership Committee, through its Chairman, Clarence Bonnell, reported that 34 new names had been approved by the Council for membership. After reading the list of candidates a vote was taken electing them to membership in the Academy.

The Librarian, A. R. Crook, handed in the following written report:

Librarian's Report 1923-1924

Since the museum has been moved to attractive quarters in the magnificient new Centennial Building, opportunity has been offered for the first time in many years to make accurate count of the volumes of reports still on our shelves.

The number of each of the sixteen volumes remaining is as follows:

Vol. I	71
Vol. II	604
Vol. III	559
Vol. IV	516
Vol. V	506
Vol. VI	230
Vol. VII	456

Vol. VIII	415
Vol. IX	1470
Vol. X	313
Vol. XI	357
Vol. XII	270
Vol. XIII	350
Vol. XIV	369
Vol. XV	542
Vol. XVI	400

The large number remaining of Volume IX is due to the fact that officers at that time thought that these volumes would be useful in spreading a knowledge of the good work which the Academy is doing. If members of the Academy will let the librarian know where these volumes may be useful, copies will be sent.

The sales of such volumes as have been published by the Academy have totalled $34.50 as indicated below:

April 17, 1923, McClurg Company, Chicago, 8 volume @ $1.50 each	$12.00
June 4, 1923, H. Garman, Uni. of Ky., Volume VI	1.50
Jan. 31, 1924, Insular Experiment Station, Rio Piedras, P. H., Volume X	1.50
Jan. 31, 1924, Minn. Uni. Library, Volumes VI, VII, VIII, IX, X, 5 volumes	7.50
April 3, 1924, Wisconsin Uni. Library, Volumes I, II, III, IV, V, VI, VII, VIII, IX, X, 8 volumes	12.00
Total	$34.50

This total has been forwarded to the treasurer.

The major portion of the expenses of publishing our volumes is met from the museum's publication fund. While there are reports which the museum desires to publish, yet the thought of the chief is that there is no better way of carrying out the work of the museum in its purpose of diffusing scientific knowledge, than in publishing the Transactions.

It is to be hoped that the time will arrive when the legislature will appropriate sufficient funds to bring out not only the Transactions but other museum publications.

Respectfully submitted,

A. R. Crook,
Librarian.

Report was accepted.

Chairman John C. Hessler, of the Committee on High School Science and Clubs, gave a report on the year's work as follows:

Report of the Committee on High School Science and Clubs, May 2, 1924

The work of the committee for the year 1923-1924 has been limited to two projects: (1) The preparation of a program for the section of High School Science; and (2) The making of a census of High School Science Clubs in Illinois.

The section meeting this afternoon will, as the program indicates, consider Science Clubs and the "Humanizing of High School Science". The thanks of the committee are extended to the men and women who have consented to contribute a share of their time and interest to this program.

The census of High School Science Clubs was made through a return postal-card questionnaire of 12 questions. The cards were addressed to 645 High Schools of the state. Up to the present time 153 replies have been received, two of them letters which go into details more specific than the space on the cards permitted. This means that about 500 of the 645 schools addressed made no reply whatever. Of the 153 replying, 105 reported no Science Clubs whatever; 16 reported no clubs at present, but manifested interest in the possibility of forming clubs; while 32 reported clubs at work. When it is remembered that last year's committee sent out 625 eight-page pamphlets, in which the desirability of High School Science Clubs was stressed, and in which suggested programs for a year's work were given, the progress of the High Schools of the state in taking up science from the amateur, as distinguished from the curricular point of view, does not seem very rapid. This ought not to surprise those who know the High Schools of the present day and the appalling number of extra-curricular activities that occupy the student's interest and time. It is barely possible that, as a result of the number of these activities already existing, a great number of the pamphlets and postal cards sent out did not reach the teacher

of Science at all, but were diverted to the waste basket in the administrative offices of the school. This explanation would account for the "lost battalion", nearly 500 schools in number, from which no replies whatever were received.

The committee chairman recommends that the work go on, and that the Academy take special pains to interest itself in, and if possible to cooperate with, those High School Science Clubs already in existence, as well as to encourage the formation of clubs in those schools in which the census reveals an indication of interest in such clubs.

In conclusion the chairman desires to read a portion of a letter received from a teacher vitally interested in Science Clubs:

"Science clubs started in the school five years ago as an experiment in the General Science classes. Chemistry Clubs were organized a year later; then followed the Botany and Zoology Clubs. All members of the class are members of the club, as the club meets during the recitation period. In this way not only the bright and interested student, but also the student who needs the incentive of club activity is reached. We find this a strong point in favor of such an organization.

There are 16 General Science Clubs with meetings every two weeks. The president of the club, elected for a semester, presides over the meeting. The program consists of simple experiments or talks on subjects relating to science in everyday life.

In Botany, Zoology, and Chemistry the same plan is followed, with variations to suit the particular need. The president and secretary are directly responsible for the program. Each student takes part. Talks on current topics, reports of outside lectures or conferences, biographical sketches, and talks on topics bearing on the subject and of general interest make up the programs. The two Botany Clubs superintended tree planting on the school grounds lately. In one of the Zoology Clubs a lively discussion of the proposed Game Reform Law took place. Each of these clubs meets twice a month.

Each of the three Chemistry Clubs meets once a month, but has a two-period session when experiments performed require the time. Critics are appointed, and a general discussion follows the talks or experiment. Two years ago a member wrote a short play for the club. This year the clubs are working on a pageant to show important epochs in the history of Chemistry.

In each of the various clubs the teacher takes no active part. He may ask or answer questions, or guide the trend of the discussion. All of the clubs with the exception of the General Science Clubs have taken excursions to plants near by or in Chicago. Moving pictures have also been obtained for use in club meetings.

The Radio Club is an after-school organization. Any one in school may join, providing he is passing in his work."

Respectfully submitted,

JOHN C. HESSLER,
Chairman.

The report was accepted.

The Secretary reported that Vol. 16 of the Transactions had been published and sent out to all members, and about 400 copies remained in the Librarian's keeping. Also reported that such reprints of the Galesburg papers as had been ordered were now in the press and would soon be issued. Report was accepted.

Chairman W. S. Bayley, of the Committee on Affiliation, reported progress, and stated that the Committee had attempted to secure a census of the Scientific Societies of the State, but was unable to do so. It was difficult to locate any scientific societies not already affiliated with the Academy. Members were urged to notify the Committee if any local scientific societies were known to them. Report accepted.

The following plan for affiliating local scientific societies was presented in two parts.

PART I

Local Academies of Science and similar Scientific Societies in the State, other than High School Science Clubs, may become affiliated with the State Academy by

an affirmative vote of three-fourths of the members of such society, when confirmed by vote of the members of the State Academy at their annual meeting. Voted to adopt.

PART II

Members of such affiliated societies may become members of the State Academy without initiation fee, by paying annual dues to the treasurer of the local society sufficiently large so that the local treasurer may send to the treasurer of the State Academy one dollar for each member, except for life members of the State Academy, or for those who are also members of the A. A. A. S. Voted to adopt.

AMENDMENTS

Several amendments to the constitution were presented as follows:

(1) An amendment to Article V, allowing two past-presidents, instead of one, to sit with the Council. The article as amended in the first sentence reads as follows: The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, the retiring President and his immediate predecessor.

(2) An addition to Article V.—At the Annual Meetings the presiding officers of all the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

(3) An addition to Article VI, providing for a Committee on Affiliation, consisting of five members chosen annually by the Academy.

(4) An addition to Article IV, providing for the selection of a second vice-president.

Said officer may be a resident of the town in which the next annual meeting is to be held, and may be appointed by the Council each year when the next meeting place shall have been decided upon.

The above amendment and additions to the constitution were separately adopted by vote.

The Illinois Nature Study Society of Elgin applied for affiliation with the Academy, and by vote such affiliation was granted.

The President appointed the following committees, to report at the business meeting to be held at five o'clock in the afternoon.

Committee on Nominations.—A. R. Crook, Chairman; H. C. Cowles, Mary M. Steagall, L. E. Hildebrand, J. C. Hessler.

Committee on Resolutions.—W. S. Bayley, Chairman; F. R. Jelliff, F. M. Colyer.

Committee on Auditing.—W. H. Packard, Chairman; G. W. Boot, C. M. Turton.

A motion was passed that a Committee on Conservation be added to our standing committee. By vote the incoming Council was empowered to appoint such a committee on Conservation for the coming year.

A letter was read from the British Association of Science inviting our Academy to send delegates to their meeting to be held in Toronto, August 6-13, 1924. It was voted that the recommendation of the Council, in session May 1st, that the delegates be appointed by the incoming Council, from among those who were to attend the Toronto meeting, be accepted.

Adjourned to meet at 5:00 P. M.

Business Meeting, Elgin High School, 5:00 P. M., May 2, 1924

President Waterman presided. Report of committees called for.

W. E. Packard reported that the Auditing Committee had examined the books and accounts of the Treasurer and had found them correct. Report accepted.

W. S. Bayley, for the Resolutions Committee, reported as follows on the death of members during the year:

It is with sincere regret that the Academy records the passing away during the past year of the following members:

Mr. C. B. Caldwell, M. D., Lincoln State School and Colony, Lincoln, Ill.

Mr. Theo. O. Edgar, M. D., Dixon, Illinois.
Mr. J. H. Jones, Evanston, Illinois.
Mr. L. H. Hyde, M. D., Joliet, Illinois.
Prof. Alexander MacGillivray, Ph. D., Urbana, Illinois.
Mr. Chas. F. Millspaugh, M. D., Field Museum, Chicago, Illinois.

Resolutions accepted by vote.

Also the Committee presented the following resolution of thanks to all persons and organizations in Elgin who had helped in any way to make our meeting a success:

Resolved that the State Academy of Science herewith expresses its sincere appreciation of the kindness and hospitality shown its members, during the annual meeting, by the citizens of Elgin.

That it is especially grateful to Mr. Carl F. Gronemann, Chairman of the Committee on Arrangements, and to all his assistants, who have rendered such efficient service; to the Mayor of Elgin for his cordial address of welcome; to the Board of Education for the use of the High School building; to the Elgin Academy and Junior College; to the Superintendent of City Schools; to the High School and Elgin Academy Officials, teachers and students; to the Boy Scouts; to the Chamber of Commerce; to the Elgin Press for its helpful notices and write-ups; to the Illinois Nature Study Society of Elgin; to the Merchant's Association; to the Elgin Watch Company; and to the Elgin Scientific Society, all of which have aided so greatly in making the 1924 meeting of the Academy of Science a gratifying success.

W. S. Bayley,
F. R. Jelliff,
F. M. Colyer.

This resolution was adopted. Copies were sent by the Secretary to all in Elgin concerned in making our meeting a success.

A third resolution was presented concerning the practice of polluting the streams and rivers of Illinois, and recommending reformatory action by the State legislature. Following is the resolution:

WHEREAS it is the common practice of many Illinois cities to discharge raw sewage, and of numerous corporations to empty factory and even chemical waste into the streams of the state, thus polluting and poisoning and rendering them unfit for domestic and, when excessively charged, even for industrial use, depriving farmers of their right to the use of said streams for stock and other purposes, and preventing the public from enjoying them for bathing and other pastimes, and

WHEREAS such abuse of the streams is killing the fish and aquatic life, and imperiling waterfowl; and

WHEREAS in the case of the larger streams such practices of pollution are making said streams offensive for navigation; and

WHEREAS the gradual diminution of other sources of water supplies for municipalities, farms and industries makes the preservation of our streams as possible sources of supplies imperative, therefore be it

Resolved that we will support the State Waterway and State Health authorities in their efforts to encourage or compel municipalities, corporations and individuals to abate the public menace created by the discharge of sewage, waste and other filth into the streams of Illinois.

Resolved that if the present law is not sufficiently stringent for this purpose, or is not applicable to municipalities, we favor the passage of such further measures by the State Legislature as will secure reformatory action.

Resolved that we favor the study and consideration of the question in the commercial bodies and schools of the State, so that the people may be led to comprehend that the present practice of stream pollution is a crime against themselves, and so that they may, therefore, be persuaded to assume the expense of providing a remedy.

Resolved that we favor the appropriation by the Legislature of a sum sufficient to enable the State Waterway Board to make a detailed survey of the streams of the State with a view to recommendations that will meet the present dangerous situation.

Resolved that we commend Decatur, Elgin, Champlain, Urbana and Springfield for the forward steps they have taken to provide sanitary drainage districts.

Committee,
W. S. Bayley,
F. R. Jelliff,
F. H. Colyer.

This resolution was adopted.

The Committee on Nominations reported as follows:

Nominations for Officers for 1924-25

President—W. G. Bain, Springfield.
Vice-President—C. H. Smith, Chicago.
Secretary—C. F. Phipps, DeKalb.
Treasurer—W. B. McDougall, Urbana.
Librarian—A. R. Crook, Springfield.

Nominations for Committee on Membership

B. K. Richardson, Springfield, Chairman.
W. H. Packard, Peoria.
J. H. Bretz, Chicago.
T. E. Savage, Urbana.
Miss Alice Patterson, Normal.

Nominations for Committee on Affiliations

W. S. Bayley, Urbana, Chairman.
Mrs. Eleanor Smith, Joliet.
M. H. Leighton, Urbana.
W. G. Waterman, Evanston.
C. A. Shull, Chicago.

Nomination for Third Member of Publication Committee

L. E. Hildebrand, Kenilworth.

The report of the Nominating Committee was accepted, and the Secretary was empowered to cast the ballot of the meeting for the officers and committees nominated. This was done and the officers and committees named were declared elected.

The Treasurer reported five new candidates for membership, and they were duly elected.

Meeting adjourned.

The papers presented at the general meetings and section meetings were very much enjoyed by the members and visiting friends. As nearly as could be calculated there were from 150 to 200 Academy members present and possibly as many visitors. The total attendance at the section meetings Friday afternoon was about 200, but this number was much increased by visitors at the general meetings. There were 73 papers presented in the 7 section meetings and 3 General Sessions. The Academy was welcomed by Mayor Earle R. Kelly on Thurday evening in a very cordial address.

On Saturday, May 3rd, many members and friends met at the High School to participate in the field trips. One group visited the Elgin Watch factory and were shown through the various departments and had the details of making a million watches a year explained. After the tour of inspection the Watch Company's Astronomical Observatory was visited where it was learned how accurate time is obtained from the stars every night.

A second group, led by Dr. M. M. Leighton and Dr. Paul MacClintock, visited interesting regions of glacial deposits near Elgin.

The third group, led by Dr. H. C. Cowles, made a study of plants and trees in Trout Park. The White Cedar swamp was of especial interest, since it is a relic of the glacial age and has no counterpart elsewhere in the state.

All these groups met at noon in Trout Park where they were served a bountiful complimentary luncheon by the Illinois Nature Study Society of Elgin. This courtesy was much appreciated by the members.

In the afternoon the Geology group continued its exploration of the glaciated regions, and the Botany group visited Hill's famous Evergreen Nursery at Dundee.

Concerning the Elgin meeting as a whole, many of the members voiced the opinion that it was a gratifying success, and that it was one of the best the Academy had ever held.

C. Frank Phipps,
Secretary.

PAPERS PRESENTED AT THE GENERAL SESSIONS OF THE GALESBURG MEETING

PLANT COMMUNITIES OF GLACIER NATIONAL PARK, MONTANA.

W. G. WATERMAN, NORTHWESTERN UNIVERSITY

GEOGRAPHY AND GEOLOGY

Glacier Park is located in the northwest corner of Montana, extending from the east front of the Rockies across the Lewis and Livingston ranges. The east front of the mountains rises abruptly from the Great Plains, as a result of the formation of the great Lewis overthrust fault which pushed the mountain strata out over the great plains formation in places as far as fifteen miles. This front or escarpment has been trenched by many streams which flow down from the plateau and find their way northeastward through the St. Mary's river to Hudson Bay or through the Milk River into the Missouri. The continental divide runs south along the crests, first of the Livingston and farther south of the Lewis Range, and the waters from the west side of the divide flow eventually into the Pacific Ocean. These streams in their lower valleys have developed narrow flood-plains, but they rapidly become steeper and their head waters are located in mountain ponds and springs on an average not more than 8 or 10 miles west of the plains. The mountain sides are very steep and are covered by slides of gravel occasionally broken by horizontal ledges formed by the protruding edges of the strata of which the mountains are composed. These strata dip gently in both directions toward a central valley between the two ranges, forming a great syncline. They are generally almost horizontal, though occasionally crumpled into many short wavy folds.

Near the summits of the mountains on protected ledges and in saucer-shaped depressions are located the glaciers from which the park gets its name. They are mostly small and decreasing in size, but they produce characteristic ridges of clay and gravel known as moraines, and their melting supplies the streams which cut narrow gorges down the mountain sides. Where two glacial valleys start opposite each other on the divide, their heads have cut the ridge down and a saddle or pass has been

formed. On an average the valley floors have an elevation of 4000 feet above sea level, the passes 6000-7000 feet and the mountain summits 9000-10,000. There are only six mountains in the park above 10,000 feet and of these the highest, Mt. Cleveland, is 10,500.

PLANT COMMUNITIES OF THE VALLEYS

The dominant plant formation of the region is the Rocky Mountain conifer forest which is found in the river valleys and on the lower slopes of the east side of the divide. The forest of the central valley and of the west slopes is similar but has an admixture of many of the species of the Pacific Coast.

The vegetation of the Great Plains adjoining the east front is of the grassland or prairie type. This consists chiefly of several species of grass with some herbaceous dicotyls, including a prickly pear cactus, and the shrubby sage-brush. In the river valleys, cottonwoods and willows fringe the streams and in smaller valleys and gullies thickets of shrubby willows, alder, and aspens are generally found. On the rolling hills adjoining the east front, aspen thickets are found and on the summits of the hills there are occasional stands of scattered stunted conifers.

In the ponds and marshy spots scattered over the prairie and along the stream valleys are characteristic aquatic communities. In most localities are the usual swamp communities including cattails, arrowhead, water-plantain, water smart-weed, and also such unusual forms as the pincushion plant, the owl-clover, and several genera of the evening-primrose family. Many of the depressions are strongly alkaline with such halophytic plants as salt-grass, shad scale, and the alkali buttercup.

The conifer forest (Fig. 1) is found at its best in the river and lake plains in the deep valleys of the east front. Here the trees grow in close stand to a height of 60 or 70 feet, and there is a dense mesophytic undergrowth of shrubs and ground plants. The chief trees are the lodge-pole pine, the Englemann spruce, the Douglas fir or false hemlock and the alpine fir. The low trees and shrubs include the mountain ash, mountain maple, the service-ber-

ry, the buckthorn, the buffalo-berry, the deerbrush, the snowberry, and honeysuckles, with blueberries, gooseberries, and raspberries. Among the ground plants are such characteristic forms as the queencup, the rattlesnake plantain, the baneberry, the pyrola, the bishop's cap, and several ferns. Occasionally rounded shoulders or knobs, usually on the north side of a valley, show very xerophytic conditions and have a vegetation resembling that of a pine barren. The trees are chiefly lodgepole and lumber pines and poplars, and they have a stunted growth and open stand. The chief shrubs are blueberries, mountain spray, and deerbrush, and the ground plants include bergamot, harebell, fireweed, beardtongue, stonecrop, and a xerophytic selaginella.

PLANT COMMUNITIES OF THE MOUNTAIN-SIDES

On the valley sides the soil rapidly becomes drier than that of the flood-plains, the trees are not so tall and have a more open stand, and the undergrowth becomes more xerophytic. The forest also becomes discontinuous, with alternating patches of shrubby thickets or of mountain meadow. In the thickets, alder and willows predominate, with elder and red osier dogwood and stunted specimens of mountain ash, mountain maple and service berry.

The mountain meadows consist of a dense ground cover of grasses and herbaceous plants which are famous for the variety and bright color of their flowers. Among these are paint brush, columbine, bear grass, mariposa lily, beard-tongues, louseworts, larkspur, Jacob's ladder, shooting star, spirea, stonecrop, saxifrages, sulphur plant, bistort, wild onions, lupines and other legumes, and several showy composites. Where there is plenty of water in the soil, as along the mountain streams, will be found the globe flower, little elephant, pasque flower, anemones, and hydrophytic saxifrages and mosses.

Farther up the mountain side the plants get more and more stunted. At timberline the conifers form extensive thickets of trees not over 3 or 6 feet tall. Above timberline there are no trees and the ground plants grow in clumps with a very open stand. All have short stems and many show the cushion habit, but the flowers are still

brightly colored and generally full size. Characteristic species are the mountain dryad, mountain pink, several saxifrages, red and yellow stonecrops, dogtooth lily, cinquefoil, mountain sorrel, mountain forget-me-not, and wild candy tuft. These plants continue in very open stand as far as any gravelly soil can be found. Among those which are found at the highest levels are the dryad, mosspink, a saxifrage, a hedysarum, a dandelion, and chickweeds. On the bare rock surfaces there is a profusion of lichens, predominantly greenish-gray, but also black and white, brown, lavender and even yellow and red.

PLANT COMMUNITIES OF ALPINE PARK.

Near the summits of the mountains, small level tracts are occasionally found which may be called mountain parks. These contain slight depressions in which snowbanks accumulate and frequently remain until late in the summer. The vegetation of these parts resembles the tundra of the arctic regions interspersed with scattered clumps of stunted conifers. (Fig. 3.) In the drier portions of the tundra, the main groundcover consists of grasses and sedges with such characteristic flowering plants as the red and white heathers (*Phyllodoce*), the shooting star, the Rocky Mountain laurel, the dwarf willow, the alpine speedwell, fringed gentian, Indian warrior, and rock cress.

The snowbanks have a different and a very characteristic vegetation. In the early part of the season, the dogtooth lily grows around the edges of the snow, even coming up through the snow and blooming before it has melted away. When the snow has completely melted, the bottom of the little hollow is found to contain not the dogtooth lily but the alpine spring beauty. The conifer clumps are usually found on the shallow dry soil which overlies rock ledges and they follow the outlines of the buried rock ridges. The species include fir, spruce, the white-bark pine, and the Rocky Mountain juniper.

On the sides of the parks near the mountain slopes, the rock ledges often protrude through the scanty cover of soil and here the plant communities are quite different.

Fig. 1. Conifer forest in stream valley. Mountain meadow in foreground.

Fig. 2. Flowers in mountain meadow surrounded by conifers.

Fig. 3. Elongated patches of stunted conifers in Alpine Park,—indicators of buried rock ledges.

Fig. 4. Moraines and rock ledges surrounding Two-Ocean Glacier.

The outer edges of the rock ledge which are exposed and relatively dry are occupied first by elongated patches of stunted conifers of the species already mentioned. The inner part of the ledge is lower and the scanty soil is watersoaked from melting ice and snow, and in this depression a moisture-loving community develops. The plants here include grasses and sedges, the heathers, and the Rocky Mountain laurel, the globe flower, a buttercup, a cinquefoil, the queencup, a white paint-brush, the meadow rue, the rock-cress, and in protected spots several delicate ferns.

When water drips over the face of the ledge, the projections and pockets in the rock face contain hydrophytic mosses and ferns, and such unusual plants as the mist-maiden (*Romanzoffia*) and the butterwort (*Pinguicula*). In especially cold, wet spots a bit of real arctic wet tundra may be found with sphagnum and the arctic heather *Cassiope*.

Still another type of community is found occupying the clay-gravel moraines around the melting fronts of the glaciers. (Fig. 4.) Here the conditions are extremely hard for plants on account of the character of the soil, and the exposure and the absence of moisture on these dry, clay ridges. The first plants to appear after the retreat of the glaciers are stunted and scattered, as they are able to become established only in the most favorable spots. The first pioneers are usually grasses, with chickweeds, fleabane, alpine beardtongue, the mosspink, and the alpine poppy. The last mentioned is especially interesting and characteristic as it is a true poppy, but only two or three inches high. It has only a few leaves and one orange-colored flower which is perfectly formed and easily recognized as a poppy.

On the older moraines these plants form layer clumps and are found closer together. Other less hardy species come in and scanty clumps of stunted conifers begin to appear. Those are the same species that are found on the dry tundra and on the rock ledges.

PLANT COMMUNITIES OF THE WEST SIDE OF THE DIVIDE

The same general conditions prevail on the west side of the divide, but the plant communities there are interesting because of the presence of many species from the Pacific coastal forests. Among the trees are the western hemlock, giant cedar, western larch, western white pine, and white birch. Among shrubs and ground plants are the yew, the devil's club, the mountain lover, and the Oregon grape. Other plants found chiefly on the western slopes in Glacier Park are the nine-back, the Labrador tea, the bunch-berry and the high-bush cranberry.

The forests of the valley floors are very damp and the heavy undergrowth resembles in luxuriance as well as in species that of the forests of Washington and Oregon. The trees are draped with the bearded lichen and there is a profusion of fungous forms on the rich humus.

In some of the ponds above the head of Lake McDonald are sphagnum bogs which resemble those of the eastern states and Canada. The characteristic feature of these bogs is the floating mat of sphagnum which supports such bog plants as sun-dew, swamp cinquefoil, and cottongrass as well as the Rocky Mountain laurel, the orchid lady's-tresses, the water hemlock, and several club mosses.

MENTAL HYGIENE AS A PROBLEM OF PUBLIC HEALTH

HERMAN M. ADLER, M. D., CRIMINOLOGIST, DEPARTMENT OF PUBLIC WELFARE, CHICAGO

The accomplishments of medical science in controlling infectious diseases both by prevention and by cure are so well known to the general public that there can be little doubt as to the main facts. In spite of the opposition of a relatively small but determined number of dissenters the science of medicine has gone on in an uninterrupted sequence of achievements. Typhoid fever, small pox, diphtheria, and tuberculosis have all yielded to the medical attack. Even in those conditions in which the etiology and specific treatment are still obscure a great deal has been accomplished in prevention. The average expectancy of life has been lengthened in one generation from thirty-three years to fifty-six years, and predictions are now being heard, based on reasonable assumptions, that the span of life will be further increased to sixty or even the Biblical three score and ten years.

It is natural that such a growing accumulation of knowledge has produced a marked effect on the community aspects of the general health problem. Public Health has developed into one of the most important agencies in the safe-guarding of the community welfare. Hygiene has made it possible for increasingly large groups to enjoy the advantages of close association in cities without the dangers to health which formerly were an invariable accompaniment to concentration of population. This ability to safe-guard health has been felt also on the farms and in industry. It has made possible the management of large armies, the conquest of the tropics and the arctics, the building of the Panama Canal. In addition to the prolongation of life and to the protection of citizens has been the progress made in the reduction of infant mortality.

Medicine has not yet reached the final triumph over disease. In spite of the advances made in cancer, heart diseases, the disease of the respiratory organs, meningitis, syphilis, and tuberculosis, these diseases still exact

too heavy a toll. But enough evidence has been obtained to indicate that however difficult the problem may seem at the moment, an ultimate victory is reasonably assured.

It is probable that most of this success has resulted from definite discoveries made often as a by-product of another research. The mere recognition of a danger or of an unsatisfactory state of affairs does not solve the problem. Discontent and rebellion, however justifiable as emotional manifestations, have not contributed much to a solution.

The functions of the Public Health organizations are largely those of applying available knowledge. On account of the tremendous urgency of the problems dealt with there is little time to attempt research. Nevertheless our Public Health Agencies have managed to contribute important new knowledge; thus diphtheria antitoxin was in large measure the result of the Public Health interests of its discoverer, von Behring.

It is natural that Public Health has been forced to concern itself within the last generation with the practical problem of physical health, and the advances in scientific knowledge have been largely in the direction of specific treatment in an increasing number of physical diseases. The advances in laboratory technique have been responsible for the preventive work on a large scale. There is one branch of medicine, however, which has long been recognized as one of the most important, but which has lagged behind the general advance in clinical medicine. This is the field of mental science. Largely due to the complexity of the problem and to the relative inaccessibility of the central nervous system to available methods, there is an apparent discrepancy between our effectiveness in this field as contrasted with the physical diseases. Nevertheless psychiatry and psychopathology have not been inactive, and considerable advance has been made of late, so that now we are in a position to apply, in some degree at least, therapeutic and preventive measures.

It is natural that the first advance should have been made in the recognition and the diagnosis of mental disorders rather than in their treatment and prevention.

This has perhaps contributed to a certain amount of scepticism on the part of those outside towards the practical value of the methods of mental science. It is interesting to note also in this connection that the extension of life and the saving of infant lives, of which medicine is so proud, have served to complicate the problem from the mental side. A favorite comment of journalists on this topic is to the effect that medicine is now saving the unfit, that we are tampering with nature's law of the survival of the fittest and thus increasing the numbers of the unfit who endanger the welfare of the more favored individuals; that all that has been accomplished has been to protect the weak and inadequate without benefit to anyone. I need not examine this argument more closely at this time or point out all the fallacies involved. The struggle for existence and the survival of the fittest may be shown to be still active even in our social organization of today. It is true that since the progress of science is uneven, inequalities may arise and that at a given moment in one or another direction the difficulties may be increased rather than lessened. Nevertheless, it must be perfectly obvious to any fair-minded observer that the sum-total of gain is far in excess of any circumscribed losses. Whatever inequalities of this nature may now exist will undoubtedly be wiped out by the further progress of knowledge and by our increased control over ourselves and our environment, to which we can confidently look forward.

The question that I wish to deal with today is not whether mental science is worth while, but rather are we applying effectively all the knowledge now available; are we dealing with such problems as those just suggested as well as we now are able. Psychiatry deals with mental disorders. From the Public Health aspect, however, it deals less with the mental disorders themselves than with a subsidiary phenomenon, namely, human behavior. Thus a person is not considered insane because his mind is deranged, but because of what he does as a result of such derangement. Every psychiatrist has observed repeated instances of individuals with gross mental disorders who

have not been declared insane, who have not presented any major problem to the community or themselves mainly because their behavior was not disordered to the degree which the law specifies is to be considered as a menace to themselves or to the community. To say that medicine and especially psychiatry now have interests, therefore, in behavior is to indicate that medicine has social relations and an interest in the social organization much more far reaching even than the social implications of communicable diseases, which are so well recognized at present. The medical attack, however, is made easier by being confined to a limited part of the problem and is not officially concerned with social problems in general. The medical interests must be based on the problem of pathology, and it is this point which I particularly would like to stress.

There is one other general consideration which I think it is important to note, namely, that the logic of medicine cannot be transferred from the clinical field of physical diseases to that of mental disorders without some modification. The generalization which covers this is perhaps best stated thus: there is no specific relationship between the nature and degree of the organic involvement in the nervous system and the behavior manifestations to which it gives rise.

It is this latter consideration probably to which we must ascribe the aloofness of the general medical practitioner in his attitude towards mental problems. The physician, perhaps merely as a human being, prefers problems in which the sequence of cause and effect can be clearly determined. Where the cause is often so elusive or so apparently insignificant as contrasted with the effect, as it is in mental disorders, both layman and physician refuse to commit themselves.

There is one specific subject in which after a very hopeful beginning a great deal of distrust has resulted. I refer to the subject of feeble-mindedness. When Binet devised his system of tests, which have since become famous, great enthusiasm was manifested because it seemed as though at last we had an accurate quantitative method for determining this important phase of mental disabil-

ity. An enormous amount of observational material has been accumulated both here and abroad in connection with mental tests in our schools, in the Army during the war, and in industry. The results seemed surprising to many, and talented writers whose imaginations were fired by some of the apparent implications have run wild in their generalizations. Evidence of the danger of too hasty generalizations in this field is furnished by the numbers of books that have come, often from the pens of distinguished writers, in regard to Race questions. Present discussions in regard to immigration often lead to bitter differences of opinion in regard to the possibility of erecting hard and fast rules based on mental tests.

The situation may be simplified in the following way: Intelligence is probably not measured directly by these tests at all, but in the ordinary individual the results of these tests may be regarded as a fair sample of the mental ability of the subject including his intelligence. For statistical use, therefore, the method is probably reasonably sound. We are dealing with the approximate measurement of a quality which is universally possessed by all human beings. It comes under the category therefore of *more or less.* It is comparable to the quality of tallness or shortness, the quality of pigmentation, and to other similar qualities. If determinations are made on sufficiently large groups the results will be observed to follow one or another curve of distribution. There is no evidence adduced so far to indicate that a particular rating on such an intelligence scale will indicate the presence or absence of pathological factors. In spite of repeated attempts to do so, all who have tried to indicate at what point on the intelligence distribution curve for the United States Army the pathological threshhold may be placed have failed. On the contrary during the war it became apparent that a very low rating by intelligence measurement did not indicate *feeblemindedness,* even though the rating was well within that regarded as characteristic of the mentally deficient. Large numbers of men thus rated were found to be extremely useful in various types of labor and employment, and in fact were more satisfactory than those who rated higher. Most of the actual

labor involved in the embarkation and debarkation of men and materials, the building of the strategic railway in France, the building of cantonments, the construction of trenches and similar hard labor was performed by men whose rating placed them in the group of the unfit.

If it is true that ten per cent of our general population falls in this classification it is a matter for serious consideration, if we are to consider them because of that mentally deficient and a menace to themselves and the community. There is, however, evidence which will indicate that there are not grounds for alarm. If we regard this matter of intelligence distribution as a matter of *more or less* a generally possessed faculty we must look for something else in order to make the diagnosis of pathology. This latter quality is not subject to the category of *more or less*, but is a matter of *all or nothing*. Like disease or deformity in the physical sphere an individual either is or is not pathological. If he is pathological then it may be a matter of *more or less*. This point of view would therefore vitiate the common belief which is often facetiously expressed in the statement that all men are more or less insane. They may be more or less intelligent, more or less mentally strong, more or less alert, more or less well integrated, but in order to determine whether they are more or less disordered it is necessary to ascertain first whether they are disordered at all or not. Applied to this mental problem, therefore, a person may be highly intelligent or he may be stupid, and it is probable that this is an inherent quality and that there is a maximum beyond which he cannot develop. This maximum is predetermined in his individual make up.

But mere stupidity, however severe in itself, is not a sign of pathology. It will be seen, therefore, that the reliance on the mental tests alone will not determine this point. Positive evidence of some special disability, inherited or acquired, must be obtained in order to identify an individual as feebleminded. This emphasis that I have placed on the importance of the pathological factors must indicate that medicine has a distinct function in re-

gard to this very large and important problem, a function which it has not exercised sufficiently up to date.

The applications of psychiatry as a part of Public Health to the behavior problems of the community are not, however, confined to the group of the feebleminded. Keeping in mind the essential importance of the pathological, it is clear that medicine has developed to the point where it is able to render a service in connection with behavior problems which are even less obviously matters of mental disorder than is feeble-mindedness. In the first place, there has been an extension of psychiatry during the last few years to include a consideration of not only the gross behavior disorders such as criminality and delinquency, but less obvious difficulties affecting the happiness and success of individuals and families. As I have said before, medical science has made it possible to live in large, congested centers of population. We have conquered the physical obstacles and we are now coping with the mental difficulties. There are a great many manifestations of individual weaknesses, of nervous disorders in themselves unimportant, perhaps, but decisive in their effect upon the economic and social life of the individual. Our experience during the war with shell shocked cases, in which the American Army justly deserves great credit, shows what correctional therapy can do in dealing with behavior problems. Shell shock, or more properly, war neurosis, belongs to the group of psycho-neurosis, hysteria, and neurasthenia. Though more spectacular than the ordinary manifestation of these disorders in civil life it does not differ in quality from the latter. The same procedure which worked so well with the military cases secures favorable results with the others. It is interesting to note, however, that the world has been dealing with these manifestations since time immemorial without recognizing that they represented a medical problem. Disciplinary measures of the crudest kind have always been resorted to in the attempt to correct such behavior. In war time summary court martial, execution, disgrace and imprisonment were always relied upon to achieve results. These same methods in perhaps less summary form are constantly being applied

in the field of delinquency and criminality. There is a tremendous work to be done by the medical profession in this field, and it is to be hoped that the public health officials will presently recognize their share in the responsibility.

While a great deal can be accomplished in dealing with the offender a great deal more can be done in the prevention of delinquency. This requires in the first place adequate recognition of the problem as a problem in pathology, and adequate provisions for administering such methods of treatment as our present knowledge supplies.

There is probably no department of our social organization in which more can be done than in the department of education. In education up to now the main emphasis has been placed upon intelligence and the acquisition of knowledge as manifested by the progress of the child through the grades and farther. A closer study of the mental problems presented by any of the ordinary grade schools, or by the high schools, as well as by the universities, such as has been carried out by the Institute for Juvenile Research in this State, especially in connection with the High School at LaSalle, by the Bureau of Children's Guidance in New York, by the National Committee for Mental Hygiene, and other agencies, has shown that many a child or adolescent is acquiring habits which are bound to prove dangerous or at best serious handicaps, on the basis of individual peculiarities or traits which in themselves need not cause such difficulties. A perfect understanding by analysis and examination before the major damage is done, before fixed habits are formed, and before the accumulation of results of behavior present insurmountable obstacles, will often save these children for effective and happy careers.

Finally there is a field in which the application of mental hygiene is beginning to make itself felt both on the treatment as well as on the preventive side. This is the field of industrial relations. Very promising work is being done here in connection with industrial difficulties, by contributions to the management of personality peculiarities and difficulties which have important bearings

not only on vocational training but on industrial assignment. Labor very frequently looks askance at any method which suggests that an attempt is being made to cajole the worker into acceptance of unsatisfactory industrial conditions. A great many attempts to ameliorate the condition of the worker through so-called welfare departments have met resistance on the part of union and non-union labor. None of these objections applies to the medical program, which is free from any implications of the sort just mentioned, which are applicable equally to the employer and the employe, and which, as all medical procedures should, has as its main objective the rendering of a service to the individual. It is therefore partisan only in the sense of being for the patient and is not concerned with any partisan struggle.

Time does not allow me to discuss in detail any of these propositions, nor to take up the consideration of many other important subjects directly connected with this topic. It is a waste of time to emphasize the importance or the urgency of the problems presented by behavior disorders. What we are concerned with is the possibility now offered to medical science through psychiatry to render a service in the treatment and the prevention of these behavior disorders with all their associated consequences of social waste, of economic loss, unhappiness and danger both to the individual and to the community. Dr. Frankwood E. Williams, Director of the National Committee for Mental Hygiene, says: "This year in this country there are 250,000 boys and girls of high school and college age, all of whom in five years will be confined in hospitals for the insane." A conservative statement would allow at least an equal number who will in five years come into serious conflict with the law. To this must be added a large number who are hopefully looking to life, who will meet with bitter disappointment and who will meet with unhappiness and unsuccess. A very large portion of these individuals can either be saved from their impending fate or at least benefited by prompt and suitable relief measures. Can there be any valid excuse for inaction in the face of such need?

THE YEAR'S PROGRESS IN PUBLIC HEALTH AND MEDICINE

W. A. Evans, M. D., Health Editor, Chicago Tribune

When you listen to a report on the progress of public health and medicine given before a meeting of this character and made by myself, you expect to hear more about progress in preventive medicine than you do about the second subject. My excuse for slighting medicine in favor of preventive medicine is that I am more interested in public health.

SCARLET FEVER

Two fundamental, scientific facts have been known for some time. The first was that some one or more of the streptococci were concerned in the symptomatology of scarlet fever. As to the causative relations of the streptococcus there were two schools. One held that this strepococcus was the cause of the disease. The other held that streptococci were so nearly obiquitous and caused so many diseases that they could not be the specific cause of scarlet fever. This school held that the specific cause was some unknown organism, but that the streptococci contributed materially to the symptoms. The theory upheld by Bristol that the rash of scarlet fever was an anaphylactic phenomenon for which streptococci was the bacterial cause, lent more support to this side of the question than it did to others.

Dr. Dochez, by the use of certain culture methods, demonstrated the one variety of streptococcus which he claimed could produce the disease, and in that way seemed to establish the primacy of the streptococcus as the etiologic agent and, at the same time, to answer the point made by Jochmann that an organism which was so widespread and caused so many diseases could not be the specific cause of scarlet fever.

Doctors George F. and Gladys H. Dick proved that a certain strain of streptococcus grown from the throats of persons having scarlet fever, when injected into susceptible human beings, produced a disease with the symptoms of scarlet fever. They extracted a toxin from this

streptococcus which they used to make skin tests for susceptibility to scarlet fever. The Dick test for scarlet fever appears to take its place alongside the Schick test for susceptibility to diphtheria.

The specificity of this streptococcus for scarlet fever seems established. The use of serum from recent convalescents as a cure for and preventive of scarlet fever was of academic, rather than practical interest. Dr. Dochez used horses to make an antitoxin. His method consisted in injecting agar culture media under the skin of the horse and then innoculating the agar pad in the subcutaneous tissue with the streptococcus. He got a horse serum containing antitoxin in curative doses on a practical basis. Drs. Dick injected horses with toxin from their coccus. They got a horse serum containing antitoxin in weak strengths. They concentrated the serum, getting a serum which seemed curative in 10 c. c. doses. Dr. Blake reported blanching of the eruption and therapeutic cure of the other symptoms of scarlet fever. At the present moment the therapeutic power of the Dick antitoxin is being tried.

With a method of bacteriologic diagnosis established, the Dick test proven and a curative serum and preventive about ready for wide clinical use, it may fairly be said that the fundamental problems presented by scarlet fever have been solved.

MEASLES

Proof accumulates that the measles organism is present in the blood stream in the earlier stages of the disease. The blood serum of persons recently convalescent from the disease produces a relatively short lived, passive immunity when injected subcutaneously. So many confirmations of this observation have been reported that we may say the fact has been established.

The New York City health department has endeavored to collect and keep on hand a stock of this immunizing serum for use in situations to which it is adapted. Recognizing the difficulty in obtaining blood serum from human donors recently convalescent from measles, they have been paying the donors for a serum.

Recognizing the weakness of the passive immunity produced by the injection of serum from convalescents and its short duration, certain French physicians follow the injection of the serum from convalescents two days later with an injection of a filtrate containing the active cause of measles. In this way they claim to produce an active as well as a passive immunity without any considerable illness. The induced immunity, it is claimed, is more potent and endures longer. The observations have not been verified.

The artificial production of immunity against measles has not made much headway in general health department practice, nor will it until some large donor animal replaces human beings as the source of supply of vaccine.

PNEUMONIA

The year 1923-24 witnessed a very great increase in interest in the control of pneumonia. This interest is shown by elaborate and extensive investigations of the disease by the Pittsburg and the Chicago Health departments. As yet, neither has reported. The Chicago Health department will gather data until September 30, and they will begin reporting before Christmas. But the very fact that the communities are manifesting their interest by studies is an advance.

VENEREAL DISEASES

The State of Illinois and the city of Chicago have taken some advance steps in the control of venereal disease during the year. From the administrative standpoint, the adoption of:

(1) Rules and regulations for the control of venereal disease;

(2) Standards of infectivity;

(3) Standard Laboratory Methods;

(4) Standard Clinic methods;

represents a gain. These rules and methods are in operation.

There is frequent complaint of lack of definiteness and detail in health ordinances, orders and rules. The courts have not infrequently criticised such laws on this ground.

The control of venereal diseases in civilian communities in peace times is under the necessity, for the first time, of establishing a firm place in the law as determined by court decisions. Thanks to the definiteness of procedure and conformity to legal requirements of these rules and regulations and standard methods, the Illinois and Chicago Health departments are helping to put the control of these diseases on firm, legal ground.

The method of curing obstinate, chronic, gonococeal infections by the use of diathermy has gained some ground.

SYPHILIS OF THE NERVOUS SYSTEM

The low penetrability of the central nervous system of the newer arsenicals used in the treatment of syphilis has been noted for some time. There are those who hold that the modern, intensive treatment of syphilis results in a higher rate of nerve syphilis than prevailed prior to its use. There is no data on which this question can be settled either pro or con.

Those who claim that there is an increase in nerve syphilis explain the increase on the theory that the membranes and other defensive agencies of the central nervous system react poorly in protecting the nervous tissue against treponema; that early comprehensive treatment prevents these tissues from acquiring power to protect against treponema; therefore, when once this organism gets into the nervous tissues, it is not easily destroyed.

Dr. W. H. Brown and others at the Rockefeller Institute offer tryparsemid as an anti-syphilitic agent with greater power to penetrate the central nervous system. Various reports on the efficacy of this agent have been made. Dr. C. F. Read made the latest of these to you today. The United States Public Health Service published several reports on the penetrability of the central nervous system by various arsenic preparations. Among those with high penetrability, in addition to tryparsemid, is sulpharsphenamine.

INSULIN

The discovery of insulin antedates 1923-24. Insulin is a pancreatic product which represents that part of the

secretion which has to do with metabolism. It is pancreatic secretion from which the digestive agents have been removed. I need scarcely say to this very intelligent audience that it is, in a certain sense, a cure for diabetes.

During the past year, progress in insulin experimentation and therapy has gone forward in two directions. First, there has been a considerably promotional effect—philanthropic, professional and commercial—to bring insulin into more general use. Second, much experience—clinical and experimental—tending to show the place of insulin in therapeutics, has been accumulated.

This experience shows that insulin is a remedy for emergencies. Given to a patient in coma, or suffering from acidosis, or in straits from diabetes, it acts like magic. For patients making the long pull—the day in and day out battle to hold diabetes in check and succeeding fairly satisfactorily—it is not indicated.

It appears that it may find a place in the treatment of other metabolic disorders, some of which have not been suspected of having any relation to disease in the pancreas, or to the functioning of that organ.

It is noted that the diabetes morbidity and mortality rates are both apparently on the increase, and the increase has been at its maximum since the use of insulin became somewhat general. The diabetes death rate in 1920 was 16.1; in 1921 it was 16.8. To the experienced person this merely means that the publicity given diabetes and its treatment by insulin has uncovered cases and deaths due to diabetes which would have been overlooked otherwise. The same phenomenon was noticed with consumption, diphtheria, malaria, syphilis and other diseases.

GOITRE

The term is used to denote increase in size or in functional activity of the thyroid gland. Prior to 1923, the prevalence of goitre in the United States, the variation in that prevalence in different sections of the country, and the parallel variation in the amount of iodine in the water of different sections of the country, has been established. 1923-1924 has been characterized by an ex-

tension of information and of the application of known facts to treatment and prevention.

That deficiency of iodine in the human body is the principal cause of goitre may be considered to be established. That the supply in the iodine reservoir is frequently deficient because the amount supplied thereto by the drinking water and other foods is insufficient, is accepted.

The reservoir supply may be exhausted by reason of rapid growth in childhood and particularly during pubescence and adolescence, by reason of the demands of the system during pregnancy and during certain infections such as tonsillitis and pharyngitis and by reason of several emotional shocks and strains.

The active principle of the thyroid secretion, a body having great powers over all physiological processes requiring iodine thyroxin, was discovered by an American, Kendall, several years ago. It is interesting that insulin from the pancreas, thyroxin from the thyroid, and epinephrin from the adrenal are all American discoveries.

The year 1923-24 witnessed a great extension of popular interest in goitre. A fair number of American cities report goitre surveys of children in the public schools. In a fair number of places, iodine in some form is given children in schools. This is sometimes given as iodide of soda, sometimes as iodine in the table salt. In Rochester, New York, and Sault St. Marie, Michigan, iodine is being added to the public water supply. In Switzerland, where supplying iodine is more of a government function than it has been in this country, giving iodine in salt has been in vogue.

Plummer has endeavored during the year to differentiate various types of goitre and the effect of giving iodine on each. There has been the beginning of an effort to distinguish between the different types of thyroid abnormality and to determine which will get well spontaneously; which tend to progress toward more serious consequences which are benefited by iodine and which are, or may be, harmed by it.

The tendency is definitely away from classifying all cases of thyroid enlargement as goitre in need of iodine and all cases without such enlargement as being without that need.

CANCER

Statistics show that the death rate from cancer is increasing. This increase is greater than the increase in population forty years and over. Part of this apparent increase is due to greater dependability of the diagnosis as given on the death certificate, and a part of that improvement is due to public education on the cancer question. It has happened with cancer, as with other diseases, that interesting the public in the disease has shown a primary apparent increase in its prevalence. In spite of this apparent loss of ground in cancer, the year 1923-24 witnessed some gains in the fight against the disease.

Operations for cancer have gained ground in that they have been done earlier and, therefore, offer a greater liklihood of permanent cure. The people and the general practitioners are diagnosing cancer in its earlier stages and some of the cases come for operation while just developing. The need of making the diagnosis before pain appears as a symptom is coming to be fairly well known. The use of radiation by radium or X-rays, or both, before and after surgical procedures, has become more general.

The evidence is increasing that cancer of many internal organs, as well as of most surface structures, can be removed with a good possibility that at the end of a five year period there will have been no recurrence.

But the valuable work of the year in cancer consists in foundation work done in research laboratories and in the field of vital statistics. These relate to such subjects as the inheritability of cancer; the inheritance laws of cancer; the tendency of cancer to appear at certain age levels; the tendency of inherited cancers to appear in certain organs; the chemistry of cancer cells; the biology of cancer cells; the effect of different kinds of radiation on the biology and chemistry of cancer cells.

Valuable research work has been done on the chemical and physical irritants which lay the foundations for cancer or which directly cause the disease.

In a very recent paper, Hoffman says: "It may properly be said, however, without fear of successful contradiction, that concerning no other disease is a larger body of facts and observations available for qualified consideration.

"It is my deliberate judgment, arrived at after mature reflection, that it is a fundamental error to seek or to hope to find a single cause responsible for the frequent and increasing occurrence of malignant growths in the human body. It seems likewise an error to look upon cancer as an entity, for the disease, both in its origin and development, varies quite considerably as it affects the different tissues."

Dr. Hoffman then discusses the many contributing causes which may be related to cancer, placing especial emphasis on overeating, too frequent eating, constipation, the refinements of civilization, changes in food, and various irritations and local poisonings.

CARBON MONOXIDE POISONING

The importance of carbon monoxide poisoning has been stressed during the year by Dr. E. R. Hayhurst of Ohio. A very considerable number of fatalities due to carbon monoxide from domestic use of gas stoves, ordinary stoves, and from automobiles, caused the introduction of proposed laws regulating stoves and stove connections to be introduced in the Ohio legislature. These proposed laws did not pass, but they were the forerunners of legislation which will pass either in that legislative body or in others.

Dr. Yandall Henderson and others investigating as a basis for advising as to the ventilation required for the New York vehicular tunnel under North River reported informingly on the proportion of carbon monoxide in the air in the wake of automobiles. He also contributed valuable information on the advantage of adding a small proportion of carbonic dioxide to the oxygen used to resuscitate persons overcome by carbon monoxide.

The United States Bureau of Mines published methods for the quantitative determination of carbon monoxide in blood as well as in air.

ETHYLCHLORIDE

Anaesthesia by means of ethylchloride has had additional trial during the year. The use of calcium and parathyroid preparations in various spasmodic disorders has made some headway.

The year has witnessed progress in the study of sunlight and other forms of light and their application in the treatment of rickets and other diseases.

THE AMERICAN HIGH SCHOOL VERSUS THE ENGLISH PUBLIC SCHOOL

F. H. Crawford, Northwestern University

It was Addison, I believe, who made the remark that it is very melancholy to consider what a little negligence could spoil us, but what a deal of industry and toil is necessary to improve us. That the industry and toil demanded is great, surely none in this gathering is prepared to dispute. But on the nature of the industry and the kind of the toil necessary there will be as many different ideas as there are individuals here present. Indeed, since education first differentiated itself as a special human problem requiring special treatment and special thought, its concrete form has ever been one of controversy.

There has been controversy as to methods of instruction, the proper age for beginning it, the length of continuance, and above all, perhaps, as to the specific nature and proportion of the various subjects to be studied. These individual points of variance are, however, evidences of the real difficulty which lies in differing conceptions of what the education process shall accomplish. The rigidly state controlled education of ancient Sparta had in view the strength and glory of the Spartan State. The monastic schools of the middle ages had a no less definite aim and for them education was a tool by which the work of the Mother Church might be forwarded. Each perhaps owed its success in a measure to the recognition of the ends which it was to serve.

And so today we must define as accurately as possible the ends which we are seeking, else we shall wander far afield e'er we know it. Since I shall confine my remarks largely to secondary education, we may lay aside at once the claims of the specialist. His requirements are so exacting and extensive that they must be left for the universities to satisfy. What then should be required of a system of education in England and America today? These two countries have, I believe, fundamentally much the same educational need, namely, the need by a representative government of an interested, informed and

thinking body-politic. This, of course, does not say that each country has arrived at the same stage in the solution of this problem, nor that they will each necessarily arrive at the same or even a similar one. Yet, the general criteria for judging a system for either country will be much the same. Now, an informed, interested, and thinking body-politic would imply some process of education involving first, the imparting of certain quantities of facts, second, the awakening of intellectual curiosity, and third, some attempt to develop independent thinking. If these three elements can be mixed in due proportion, the result should be a type of education suited to the purpose in hand.

But just what constitutes a "due proportion" seems to be the snag. One class lays the greatest emphasis on the first requirement and maintains that any system of education is hopelessly incomplete and narrow which has not given the student a little Latin and mathematics, some acquaintance with English Literature, some German or French, a little ancient and modern history, political government, some manual training or needlecraft, a modicum of chemistry and physics, a bit of bird study, etc., etc., or in fact, which seems to slight any field of human knowledge. They unconsciously proceed on the theory that since no one knows exactly what he is going to do in later life, he should be given such a breadth of useful information that there is bound to be some of it which he can use later on. Needless to say, their program is so ambitious that they do not have much time for the other two requirements. They represent what we might term the adherents of the "fact-education" idea.

Another school, while recognizing the necessity of mastering a certain number of facts, argues that education is not altogether a process of accumulating predigested ideas on a world of isolated facts, but is rather a disciplining of the will and a training of the mind in correct mental processes; that it is a fitting of the recipient of this training to use his mind in solving the difficulties which life presents; that, further, it is an awakening of a craving for knowledge and an imparting of the means for self-satisfaction of this craving. They proceed on the

theory that the nature of the facts which one is to need in later life, whether he go on to a university or not, is of so problematical a nature that the best we can do is to insist on the mastery of a few fundamentals, such as English and mathematics. The rest of the time should then be spent, not jumping frantically from one thing to another, but in studying intensively subjects designed to give the maximum of mental training and discipline and at the same time a cultural outlook on life. They hold to what we might consider as the "mind-training" conception of education.

Let us now examine the American and English systems of secondary education, the former being, as I conceive it, an outgrowth of the first viewpoint, and the latter of the second. The mechanical details of the American High School are too familiar to detain us long. The work of the average four years falls into 16 more or less disconnected "subjects", each studied as a separate and unrelated field. As a rule, except for the requirement of three years of English and probably two of some foreign language, (and even this varies somewhat from place to place) the pupil is left to choose pretty much as he likes, so the specified number of subjects are taken and he arrives at the end of the four years with the required minimum of credits. Now from the point of view of the "broad-education" advocates, this system is ideal. By due choice the whole realm of knowledge can be visited in the short span of four years and there is no danger of turning out narrow specialists, for the pupil has never spent an appreciable length of time on any one subject.

It has nevertheless its disadvantages. The individual fields being taught from set text books in set courses come to be regarded as residing in water tight compartments, and the student is never taught and seldom has time to study out for himself the relationships which connect the various fields and join them one with another. As a result, he takes the facts as they are given, memorizes them blindly, or at any rate such ones as he finds necessary and lets it go at that. The idea of reading outside of a text book, in other than novels, has never occurred to him. Furthermore, it has seldom, if ever,

been pointed out that such reading is one of the most lasting sources of enjoyment and self-improvement. In fact, the whole atmosphere of the modern high school seems to be that of fitting out the pupils with a cargo of miscellaneous information with should last him until he has reached the allotted three score and ten. Our educators tacitly ignore the necessity or even possibility of continued reading and study once the pupil has left school, and make no apparent effort to train him towards this end. The result, of course, is natural enough. If he is not to read or study by himself when he has finished school, it is obviously desirable to load him up with as much information as the time will allow.

The result of this, also, is only too obvious. Since the world of knowledge has reached the bounds which it knows today, it has become humanly impossible for even a man of unusual attainments to acquaint himself more or less casually with the more important portions of it, even in the course of an entire life time. Yet, what this man of talent finds difficult in fifty odd years, we cheerfully attempt in the case of immature youths in the space of four years. Just at the time when the pupil should be gaining a thorough mastery of his mother tongue, should be receiving that strict mental discipline from which man can benefit only in youth, and should be acquiring those mental traits which will guide his reading and study in later life, just during these four precious years his time is being squandered in a hasty, shallow, sciolistic survey of knowledge. In an attempt to do the impossible we allow habits of carelessness, superficiality and inaccuracy to develop which constant effort in later life is often unable to eradicate.

The average pupil has never learned the elements of how to study. He leaves the high school a poor speller and unable to write a page of English without committing the grossest grammatical errors. In this anyone will concur who has had any experience with freshmen students entering the universities and colleges. Since usually more time is devoted to English than to any one other study, his attainments in other fields must be tragically

meagre. And, presumably, the greater share, at least, of those who go on for further education are among the better products of the high school. What level the rest have attained must from inference be very low indeed.

Of course, we must recognize that a unique feature of the American High School is its comparative freedom to all, regardless of financial condition. In some ways this very freedom has defeated its own ends, being responsible in some measure for the deplorable results we have just mentioned. It has brought such an overwhelming increase in numbers and consequent lowering of the general level of ability that standards have been forced to descend. The large classes and the need of keeping each class together have necessitated holding the brightest and most eager back to the level of the slowest and dullest. Our whole system seems designed for the lazy or inept pupil. How much budding genius we are stifling yearly I shall not even venture to guess. It is too solemn a thought. But, since genius or even conspicuous talent is so rare, and its contributions to the welfare of the human race so precious, it is permissible to question whether a poorly trained class of mediocre ability, obtained at its sacrifice, is worth the price we must pay. If we believe with that learned old Frenchman and staunch friend of Thomas Jefferson's, Pierre Samuel du Pont, that "a single day in the life of an educated man of genius is worth more to the world than the labor of a hundred thousand average men for a year", we shall agree that the price has indeed been very high.

Let us now turn to the English Public School, the details of which are somewhat less familiar on this side of the water. It might be well to remark at the outset that the schools, commonly known as "public", included, up until some thirty years ago, nothing but distinctly private institutions. They were consequently residential schools to which the scholars were sent, at a tender age, to remain during the greater part of their youth away from home. This feature I have always regarded as one of the most objectionable arrangements of the older system. During the last thirty years, however, state-aided and municipal schools have grown to a remarkable ex-

tent. These latter schools are free for non-resident pupils and have a number of free places awarded on the basis of scolarship and promise for resident pupils. They are not coeducational, the boys and girls attending school in separate buildings. The increasing number of pupils residing at home and studying at school during the day is an encouraging development of the last two decades in both types of schools. The so-called free or semi-free (i. e. schools receiving some state aid) schools have grown to such an extent that today in point of numbers they far outrank the older Public Schools, of which Eton, Rugby, Harrow and Shrewsbury, to mention only four, might be cited as typical. But, despite their relative fewness in numbers, these older Public Schools have, on account of their age, large endowments, and strong traditions exerted a preponderating influence on the development of the newer ones. This influence has been felt not so much perhaps in the exact nature of the curricula, as in the general methods adopted and standards set up. For this reason we shall confine our attention to these former as typifying the standards generally striven towards, even in the smaller and less well equipped institutions.

The study following the primary school covers six years, or "forms", the first of which is entered usually at the age of twelve or thirteen years. This six years the boy devotes to the study of Latin and Greek, the English language and literature, mathematics, one modern language, usually French, history, and, if he so elect, some natural science. Aside from the presence of Latin and Greek, the method of instruction differs most radically from ours in that the pupil studies so few things at a time. Thus, during the first three or four years he may spend practically his entire time on Greek, Latin, English, and mathematics. Then come French and history and more Latin and Greek or mathematics. If he so elect, he may devote less time during the latter part of his course to the classics and take up some one natural science, as physics, or chemistry, or botany. The point is that the pupil studies but a few things at a time, usually two or three, and continues his study of them over a

period of years in such a way that he really begins to get into the subject and thoroughly masters at least the fundamentals of it. As the pupils advance, the instruction of the brighter and more apt ones becomes less formal and they are taught to rely upon themselves and in a limited sense to direct their own efforts. Particularly able students may be allowed to spend the last year on two or even one favorite study, and through it all there is a constant insistence on mastery of anything attempted and a desire for thoroughness which cannot be compared with anything with which we are familiar.

Now the product of this system will appear on first sight to be rather narrow in his training to the average American. Let us look at him more closely. He has acquired a good knowledge of the Greek and Latin languages and at the same time a knowledge of these peoples, their philosophy and their history; he, even on the average, has had more mathematics and has it more thoroughly than the average sophomore in our colleges or universities; he can read French with some comfort; he has a good knowledge of the history and literature of the English people, and further, he speaks precise, correct English and writes in a clear, often bright and forceful style. If he has elected some natural science in place of the classics during his last two or three years, he has had usually the equivalent of two years of science of college grade. What is perhaps most valuable of all, he has cultivated the habit of reading and has learned how to study and how to think.

If I have analyzed the situation correctly, the application of the "fact-education" idea has reached an extreme with us from which we must soon return or our secondary education will become little short of a farce. I quite agree that a "broad foundation" is a desirable acquisition, but so far have we pushed the idea that the result has ceased to be a foundation at all. It has become so thin that it disintegrates (if it ever were integral) into a mass of detached units, a hopeless hodgepodge of half remembered and undigested facts. Even in the best schools when such an array of material has to be absorbed in so short a time, much thought or digestion of ideas is precluded.

The process usually descends into one of blind memory work on the part of the better pupils, and of slipshod half-learning on the part of the rest.

Of course, a good memory is an asset in any field of activity and quite indispensable in many. And if the system did nothing but train an accurate and tenacious memory, it would have certain recommendations. Most of us will admit that it does not do this; everything is skimmed over too rapidly and too many things are skimmed for the mind to get a fact hold. But supposing it did do this efficiently, could this be accepted as the rational aim of the educational process? After all, the memory is only the raw material warehouse of the mental factory, and if we spend so much of our time piling material into the warehouse that we cannot even sort it and label it, much less polish and align the mental machinery which is to employ it, how can we expect any results? To use another analogy, it is like providing a vehicle with a tank filled with a mixture of oil, water, and gasoline, and an engine in the form of the rough castings from the foundry. The oil, water and gasoline must be separated and put into separate compartments; the various parts of the engine must be milled, fitted and assembled. Then, and then only, this vehicle is ready to proceed somewhere other than down hill.

Just what our system fails to accomplish the development of the "mind-training" system of education realizes, at least in the main. The dogged insistence on thoroughness which is so characteristic a part of it, and the length of time devoted to each study insure the retention of a large number of connected facts and allow their being organized and more or less digested in the student's mind. The large attention paid to mathematics, and in this to original problem solving lacks its complete counterpart with us, as does also the general types of work usually designated by us as mental gymnastics. We are inclined to become rather impatient when anyone mentions the translating of difficult meters into Greek hexameters or the composing of original poems in Latin. We fail to see what an accurate training is necessary before they can be attempted and hence what a stage of develop-

ment their creditable execution reveals. The ability to do this must not be regarded, as has been remarked, as a mere virtuosity but as the symbol of an active and well trained mind. They ask, and justly, if the mind is not to be trained beforehand to reason and think how it can be expected to do so at all efficiently once it finds itself confronted by the actual problems and perplexities of life. Then the problems are real and success or failure may be the price of incorrect or faulty solutions.

On the other hand, the artificial difficulties set up for solution in school can bring no loss by occasional failure. They, moreover, give the pupil that healthy exercise in doing hard things, in untwisting knotty problems, and overcoming real difficulties which is of such incalculable value. We have the tendency to make everything too easy, perhaps a bit too sugar-coated, with the result that individuals trained under our system seldom gain, even in after life, the intellectual independence and self-reliance, the seeds of which should have been planted in school days.

Just after the war I saw a letter written by a prominent officer in the English navy on receiving news of the death of his old Greek master back at school. He was commenting on the various things which he had studied while in school and of their relative value in his after life. It seems that he had been put in charge of one of a fleet of nine destroyers and commissioned with the location and destruction of German mines in the British Channel and the North Sea. It was soon discovered that, in order to facilitate the laying of the mines and the marking of their positions, the Germans had taken to laying them in more or less well defined patterns, some rather simple and the rest very complicated. When a newly laid mine field was discovered, either by accident or as the result of search, a dredging process was resorted to until half a dozen mines had been located accurately. The problem of the commander was to take the positions of those which had been located, decide on what pattern the field had been laid and predict where the other mines were to be expected. In case correct conclusions were arrived at, a mine field of several dozen mines might easily

be destroyed completely in a few days, whereas, by mere cut and try methods, as many weeks might be required and in the meantime a transport ship and several of their own cruisers might be lost. In this letter, the officer went on to say that one particular year's work had meant more to him in this work than all of the rest of his study; and this was a course in deciphering ancient Greek inscriptions which he had taken with this same Greek master.

Now, on first sight, ancient Greek inscriptions and mine fields appear to lie at the very antipodes of unrelatedness. But it seems that this old teacher of Greek was accustomed to take the more advanced boys, who had their Greek pretty well in hand, and set them to deciphering inscriptions in which endings, odd words, and even lines were deleted. The pupils then were required with their knowledge of Greek life and manners as a background, and their knowledge of the language as a tool to decipher the puzzle. They must then give good reasons for every insertion which had been made. The result was that, far from being a mere puzzle contest, where a premium was put upon lucky guess work, the course developed habits of independent thought and logical reasoning. "This course", the officer said, "was of more value than all the rest put together because it really made us think, and beside it the years spent on Latin, history, etc. were quite wasted." He perhaps, however, did not stop to realize that it was the mental discipline acquired in mastering these other subjects which made this particular course of value and that without the habits of thoroughness and accuracy derived from them it could not have succeeded in the first place.

I have not given this illustration as an argument for the immediate introduction of courses in deciphering Greek inscriptions into our schools, but rather to illustrate the fact that in nine cases out of ten it is not the specific things which are studied, aside from the fundamentals, so much as it is the ability to reason and think through difficulties which is of most value in after life.

Now I do not wish to be thought of as holding a brief for the English Public School. It has its faults as has

our own. It has a certain tendency to get out of touch with the world and, in the case of the older public schools, tends to foster a class consciousness which we are striving to avoid. In its best form the system is also rather expensive, and hitherto the policy of the local governments has been to enlarge and give financial assistance to private institutions already in existence and to build and equip new ones of their own only when no others were near at hand. In proportion to the aid received from public funds the semi-private schools have lowered their fees so that we have "public schools" ranging from the free Public High School as we know it to the distinctly private schools of the older foundations. I have mentioned the rather unfortunate practice of sending children away from home at a comparatively early age, a practice necessitated at first by the fewness of the available schools and continued now largely because it has become the respectable thing to do. Its gradual decrease is a noteworthy feature of post-war England.

The American system has been conceived on a larger scale and does reach a correspondingly greater proportion of the population. I wish to point out, however, that in our satisfaction at having created a system of secondary education free to all, we are inclined to be blind to its most glaring imperfections.

Since the English public school receives its pupils a year earlier and keeps them a year longer than our high school, we cannot expect to cover a similar field in as thorough a manner. If we are to make the most effective use of these four years, however, we must, I feel, give serious thought to a somewhat radical rearrangement of our present methods. If we once realize that mental discipline is of more fundamental importance than mere memorizing of facts, and that training of the mind rather than attempted acquiring of possibly useful information should be the primary aim of education, the difficulty is half solved.

In the light of this I should suggest that four years might well be devoted to the following:

1. *Latin or Greek.* The mental discipline of study in a foreign language is unsurpassed, and no foreign lan-

guages can give the insight into the structure and use of our own mother tongue as do these root languages of English.

2. *Rhetoric and English Literature.* Accuracy in languages and fluency in his mother tongue should be the first marks of any educated person.

3. *Mathematics.* The rigorous training in exactness, the wide scope for development of originality in problem solving can perhaps be surpassed by no other study.

4. *Physics or Chemistry.* I have selected the exact sciences rather than Botany or Zoology, not only because they are fundamental to later work in any field of science, but primarily for their greater emphasis on exactness and their consequent higher value as discipline.

Time might also be found for a certain amount of history, though I do not consider it as well adapted to the purpose as those above. Moreover, a pupil who has had the vigorous training of the above schedule could acquire all the history he might reasonably be supposed to desire in the reading which the spare time of his first year out of school could provide.

It is quite possible that such a program could only be put into effect by selecting the upper one-fourth in an entering class and furthermore, the success of the whole undertaking would depend upon the training of the teachers who undertook it.

The day may never dawn when the program which I have outlined will find its exact counterpart in any school in this land, but I am firmly convinced that if our much boasted free education is not to become as valueless as it is free, we must return to the principle of fundamentals first; we must demand mental discipline in place of purblind memorizing, must exalt thoroughness above sciolism.

THE GLACIAL HISTORY OF THE ELGIN REGION

M. M. Leighton, Chief Illinois Geological Survey

The City of Elgin is situated in one of the most interesting glaciated localities of the country. The surrounding landscape portrays in remarkable fashion the architectural work of the great ice sheet. A great deal of study has been given the glacial history of this portion of the State by various workers, including Professors Chamberlin, Leverett, Trowbridge, MacClintock, Goldthwait and others, but there are still details to be deciphered. Notwithstanding the fact that the full history is not known, it nevertheless may be of interest to recite the facts as we now have them in hand, subject of course to the results of future study.

PRE-GLACIAL HISTORY

Before the glacial period, this general area had a markedly different aspect from its present. Before the incursion of the first ice sheet, this was a territory of limestone hills and valleys, mantled with such soil and residual clays as result from the weathering of the Niagaran dolomite. The present valleys, with their erratic tributary development, were not here, but instead a system of valley development of the leaf-like or dendritic form similar to that of the driftless area of northwestern Illinois, although there was less relief. The present topography has come about from a heavy mantling of this old erosional landscape with glacial drift deposited in a series of recessional moraines with intervening belts of ground moraine. The uplands at the present time have an altitude of 900 to 1000 feet above sea level. From the records which we have of well drilling, the bedrock has an altitude of approximately 650 to 700 feet. In other words, if the old bedrock topography were to be restored, a glacial drift which ranges in thickness from 100 to approximately 300 feet would have to be removed. Clearly, the deposition of the glacial drift in the Elgin area has revolutionized the old topography, giving the country a markedly different aspect from what it had previously.

GENERAL HISTORY OF THE ICE INVASIONS

For more than a score and a half of years it has been known that the glacial period was a complex period of ice invasions, rather than a single epoch; that it included five distinct glacial epochs separated by long periods of warm climate, each interglacial epoch being in most cases much longer than the time since the last glacial epoch.

Records of the earlier ice invasions, however, are not to be seen in the Elgin region. Most of the earlier glacial history has been worked out in other parts of Illinois and in adjoining states, rather than in this area. We feel quite certain, however, that this territory was transgressed by at least three different ice sheets, although the full record is not visible here. Old soils separating glacial tills have been penetrated by various wells in this locality at depths ranging from about 40 to 137 feet. These old soils are striking evidence of one or more of the interglacial epochs when the climate became so mild that the ice sheet was melted away and soil making processes were active.

While it can not be claimed that the Elgin area is a type locality of the older drift sheets, it does have the distinction of showing in a way perhaps unsurpassed by any other locality in this or any other state, the late glacial history.

MORAINAL BUILDING

At the time of the invasion of the Wisconsin ice sheet, the basins of the Great Lakes had outlines somewhat similar to their present ones. The concentric arrangement of the moraines about these basins shows that the basins caused the ice to become organized into fairly distinct lobes with radial motion. In the case of the Lake Michigan lobe, the general direction of ice movement was southward, with radial motion towards the east and west sides. In the Elgin locality, the direction of the ice movement was to the southwest. The greatest extent of this ice sheet was to Peoria and Shelbyville on the southwest. With oscillatory changes in climate from cold to warm, the ice front began its recession, but the oscillatory nature of these climatic changes brought about halts or

readvances of the ice front so that at different stages of retreat moraines were built along the margin of the ice during the time that it was temporarily stationary. These moraines, named from the outer to the inner, are now known as the Shelbyville, Cerro Gordo, Champaign, Bloomington, Marseilles, Minooka, Rockdale, Valparaiso, and the Lake Border System.

Elgin lies just beyond the outer limits of the Valparaiso moraine. Driving westward from Elgin along the Grant Highway, one crosses two of the outer morainic belts, one of them about three miles west of Elgin, the other about eight miles west. The hummocky character of these belts, their strong undulations, the promiscuous arrangements of hills and depressions are the product of unequal glacial deposition at the front of the ice during two of its halting stages.

The next stage of recession is recorded by the northwest-southeast trending moraine which crosses the Fox River Valley just south of Algonquin. Further recession of the ice took place, during which a great amount of outwash poured forth in the Crystal Lake and Dundee localities, but the moraines built when this high outwash was laid down were later overridden by the ice which made the Valparaiso moraine, thus adding to the complexity of the morainic topography of the Valparaiso system.

THE LAKES OF NORTHEASTERN ILLINOIS

It is a familiar fact that the great majority of glacial lakes of Illinois are situated in the northeastern part of the State, lying chiefly in Lake County, giving that county its name. This territory is genetically a part of the beautiful lake country of Wisconsin, and its origin involves a consideration of most unusual conditions.

Such picturesque bodies of water as Fox Lake, Grass Lake and Pistakee Lake date back in their history to the formation of the glacial moraines of the Valparaiso system, when apparently the ice movement was vigorous, the rate of melting of the ice was rapid, and large portions of the ice became detached and buried and entered into the composition of the moraine for a brief time. If this is true, the present topography is not the original topog-

raphy that existed when this particular moraine was built. The moraine then had a greater continuity and greater mass than it now has. When the ice blocks melted, these portions of the moraine lost their identity as elevated parts and became basins which are now the sites of these lakes.

The concentration of lakes in this part of Illinois raises the question as to why this should be. It is also to be noted that the moraines of this part of the State have a much greater content of stratified gravel than the moraines of the rest of the State, and that the topography is rougher, more hummocky, and possesses more of the kame and kettle features than the rest of the moraines of the State. All of these features indicate that the drainage from the ice sheet in this territory was much greater than in the rest of Illinois. This was evidently due to two things: (1) The conjunction of the Lake Michigan lobe with the Delavan and Green Bay lobes was such that the radial movement of these ice lobes was opposed to each other, resulting in the ice becoming greatly riven and crevassed, thereby facilitating melting and drainage; (2) The surface elevation at the conjunction of these lobes was lower than that of the summit of either lobe, hence there was concentration of drainage from the surface of any two adjacent lobes. With great quantities of water, therefore, pouring forth from the ice sheet in this territory, the finer materials of the glacial debris were carried away, leaving the coarser materials deposited in the form of sand and gravel hills commonly known as kames, and in the form of outwash plains and valley trains.

What has been said thus far in regard to the lakes in the morainic belts does not apply, however, to such lakes as Crystal Lake. This beautiful body of water does not lie in a terminal moraine; it is surrounded by an outwash plain. It appears to have originated from a detached block of ice, a mile and a half in length and a quarter of a mile in width, having become detached in the recession of the ice and surrounded and buried by the outwash gravels, later leaving a basin for the inundation of the lake water. This general territory in fact is

a territory in which pitted outwash plains show a most remarkable development. East of McHenry on the east side of Fox River there is an outwash plain dotted with numerous pits, yet made up entirely of gravel which has a uniform summit level.

THE FOX RIVER VALLEY

The Fox River Valley appears to have had its inception in the period following the deposition of the high outwash plain at Crystal Lake, Carpentersville and Dundee. This is well shown northeast of Algonquin where 160 feet above the present river the outwash deposits lie at the summit of both valley bluffs, the valley itself being sharply entrenched. It is very clear from these relationships that the Fox River Valley was cut subsequent to the deposition of the Crystal outwash plain. It also appears from the contour of the valley walls that the cutting of this valley was rapid and was accomplished by a large volume of water. We do not know the source of this water, because the later moraines to the east obscure the topographic conditions which prevailed at that time, but it is conjectured that the Fox River was an outlet of the Great Lakes, similar to the old Chicago outlet but before the deposition of the Valparaiso moraine.

Following this period of valley cutting, there was a readvance of the Wisconsin ice, and it is to this advance that the Valparaiso system of moraines is due. The ice appears to have advanced as far as West Chicago and within two miles of Elgin, and two miles of Algonquin, a notable moraine known as the West Chicago moraine marking its limit. Two miles northeast of Algonquin this moraine descends into the Fox River Valley within about 50 feet of the valley floor, which fixes the age of this moraine as later than the carving of the valley. From the front of this ice and subsequently from the ice which built the Cary moraine, water poured down the Fox River loaded with sand and gravel greater than the transporting power of the stream, resulting in a partial filling of the valley to a height of 80 to 90 feet, near Cary, producing a valley train which may be traced with decreasing height down the Fox River to Ottawa at its

union with the Illinois. The valley train, however, does not exist today in its entirety, but only as remnants of terraces.

In addition to the Fox River valley train, other outwash deposits were made in the form of outwash plains. A remarkable example of this occurs east and southeast of Elgin. Here these enormous gravel resources are being drawn upon for our railroad and highway building, in addition to other phases of the concrete industry, and the topography is being markedly changed by the activities of man so well displayed in the pits of the Chicago Gravel Company.

This gravel outwash occurs at a distinctly lower level than that at Dundee, Carpentersville, and Crystal Lake, and is later in origin than the cutting of the Fox River Valley, whereas the Crystal Lake gravel deposits just mentioned are older. This conclusion is based not only upon the difference in level at which the two deposits occur, but upon the fact that the higher gravels are found to pass and to continue eastward beneath the Valparaiso moraine for a distance of approximately six miles in McHenry County, whereas the lower gravel plain has its source in the Valparaiso moraine.

THE CLOSING STAGES OF THE GLACIAL PERIOD

After the ice had readvanced to within two miles of Elgin, and built the outer Valparaiso moraine, the climate became such as to cause the recession of the ice by stages, with the resultant building of recessional moraines to the east until not only had the entire Valparaiso system been developed, but also the Lake Border system, and the ice had receded to within the basin of the Great Lakes. From this time forth, the average severity of the climate decreased, the lake levels shifted from time to time as the lower outlets were uncovered by the receding ice or shifted by the warping of the land surface, until finally the North American continent was freed of this active and colossal geologic agency which had so thoroughly revolutionized the topography of the land surface upon which it encroached.

Judging from the freshness of contour of the glacial moraines from the meager amount of gullying which has taken place, except under special conditions, and from the small amount of slope wash which has gone on, it appears that the increasing warmth responsible for the melting of the ice made possible also a rather prompt reinvasion of the plant kingdom followed no doubt also rather promptly by a return migration of the animal life.

We do not know the precise length of time that has transpired since the glacial period, but recent studies seem to show that it has been something like 20,000 to 30,000 years since the building of the outer moraine of the late Wisconsin, which would correspond with the building of the West Chicago moraine which lies just east of Elgin.

PLANT LIFE IN THE ELGIN REGION

H. C. Cowles, University of Chicago

(Paper not handed in for publication)

PAPERS ON BIOLOGY AND AGRICULTURE

SOME RADICAL DEPARTURES ON THE TEACHING OF BIOLOGY

ELLIOT R. DOWNING, THE UNIVERSITY OF CHICAGO

The psychology of science teaching is now sufficiently clarified and the experimental determination of the relative values of method of instruction sufficiently advanced to warrant certain radical changes in our courses of study in biology and the technique of presentation.

All subject-matter should be eliminated from the course that is not socially worth while, and at the same time of prime interest to the pupils. The only justification for the taxation of the people to cover the expenses of the education of their children is that education contributes to the efficiency of those educated as members of the community. Interest is a prime prerequisite. For any educational process is the result of self activity and that is conditioned in its intensity by interest. We know from the studies of Mau, Finley, Trafton, and others that pupils are interested primarily in the activities of animals and plants, their identification and relation to the environment—not in their structure, classification, utility. Further, that the interest is chiefly in birds, insects, and common mammals among the animals, and in wild flowers, trees and garden plants. Our biology should deal largely with these groups and it should be concerned chiefly with behavior and environment relationships.

The subject-matter should be organized in relatively small units, with topic titles that challenge attention, for the mental grasp of High School sophomores is not extensive. The pupil needs to progress by small, well defined steps, so that he may have a constant sense of mastery and not feel lost in the intricacies of a hazy, large subject.

The unit, or a small group of them, should eventuate in a comprehension of a biological law or generalization of major social importance, because in proportion as one gets his knowledge generalized is it applicable to a new situation, and then only as he has had drill in such application. The teacher must therefore spend time in

carrying over these biological generalizations into life situations. A few such general laws well selected for their social values, well mastered and applied, are of real value. A mass of unorganized biological detail is useless.

Many of these units should be organized in problem or project form to give drill in accurate methods of scientific thinking, for such ability is more important than the acquisition of knowledge. Some units should be organized with a view to giving an aesthetic appreciation of one's environment, others to give an appreciation of the value of science and of the devoted labors of scientists; some to develop a sense of the lawfulness of nature, and the moral obligation of the student to obey her laws.

The recent experiments of Cunningham, Cooprider, Anibal, and others have shown that as far as the acquisition of knowledge is concerned, the lecture demonstration is more efficient than the laboratory method of instruction, and much more economical of time and material. Science instruction is neglected in the small High Schools because of the unjustified notion that expensive laboratory equipment is essential. The cost of instruction per pupil in the sciences is well toward the top of the list in high school subjects. The writer is convinced that we waste a large amount of time of students in muddling around in the laboratory. Teach them by the lecture demonstration method. Reduce laboratory work to a minimum. Bar the compound miscroscope from the High School biology course, and replace it with the demonstration projection microscope. Omit all dissections by students; such a dissection is rarely instructive—it is futile hash. Use prepared dissections when structure is to be studied, remembering that such studies are to be made only when structure is essential to a comprehension of activities. Omit from the notebooks all detailed sketches and replace them with diagrammatic drawings. Ayers investigation has shown that such drawings are much more efficient in fixing in mind the essential points.

In working out problems and projects, the early work should aim to habituate the pupil to the solution of a problem in the logical way, by following the detailed guidance of the teacher. Gradually the teacher's help should be withdrawn as the student is instructed in the essential steps of the problem solving process. Finally the pupil should be led to work out his individual problem or project unaided.

CERTAIN DIFFERENCES BETWEEN TEXT-BOOK EARTHWORMS AND REAL EARTHWORMS

FRANK SMITH, UNIVERSITY OF ILLINOIS

This paper deals with earthworms of two quite different kinds; those that are found out of doors, in which I have been interested for the past 30 years, and those that are found in text-books, in which I have become interested more recently. During the 30 years that I have been interested in the outdoor varieties I have spent considerable time in collecting species in various parts of the country and have examined a great many collections made by others. This has led to the discovery and description of several new species not previously known, and also has made clear that in almost any locality in the United States there are likely to be several species that may properly be called common. In most of the northern and eastern states, the most abundant forms in random collections brought into school rooms and laboratories would commonly include several species which are also very common in Europe, and they have been introduced wherever Europeans have settled and cultivated the soil for many years. Introduced of course unintentionally, they have thrived at the expense of indigenous forms and to some extent have replaced them in the long cultivated areas. In the Northern tier of states most of the common species belong to the family Lumbricidae, but include several different species of at least three different genera. In the latitude of Illinois and farther south, representatives of other families of earthworms are abundant, and in many cases include the largest of the specimens collected. Anatomically these are very different from Lumbricidae. It is no more reasonable to talk about "the common earthworm" than it would be to talk about the common species of bird or the common kind of fish. It is done in 29 of 47 text-books recently examined.

My interest in the text-book varieties of earthworms has been increased recently as a result of a historical study of the development of our knowledge of Lumbricidae in general. *Lumbricus terrestris,* which includes

the largest fairly common species of northern Europe, was the first species to be carefully and also carelessly described by European workers, and naturally was the species adopted by text-book writers of England. Earlier American text-book authors have followed in their footsteps, for the greater part, and this has been feasible since *L. terrstris,* or *L. herculeus* as it was formerly called, has become fairly abundant in our northern states and is supplied by dealers. In most cases this text-book *L. terrestris* is the one which was known a half century ago before the use of the serial section method of anatomical study. It is quite different in some respects from the outdoors *L. terrestris* as made known by more recent investigations, which very few of our text-book authors have consulted.

"The common earthworm" is a variety which is met with very frequently in more recent text-books, but not in collections. As described in a new text-book which appeared within the last year, this variety would seem to be a hybrid form from ancestors belonging to two different genera of outdoor species, which has also acquired some additional characters found in none of them.

In so far as time will permit I wish to deal with three different topics: viz, the calciferous glands, certain blood vessels in the anterior dozen somites, and the position of the nephridiopores, and will compare text-book statements with facts.

I have no disposition to criticize any teacher or writer who decides against the advisability of giving attention to the calciferous glands, but I do protest against the incorrect statements that are found in the text-books that make a pretense of giving information about them. We will first give attention to the calciferous gland of the extremely abundant species *Helodritus caliginosus trapezoides.*

An essential feature is the peculiar modification in the structure of the wall of the esophagus in the somites 10 to 14. In these somites, the muscle layer of the wall becomes separated from the inner epithelial layer, and the space between them is divided into a series of longitudinal chambers which are separated by flattened lamellae

that are radially arranged around the lumen of the esophagus. These chambers seem to end blindly at their posterior ends, which are in somite 14, or at the anterior margin of 15. In most species commonly studied in the laboratories, the esophageal wall in somite 10 is evaginated into two lateral pouches, one on each side, often called esophageal pouches, which retain the communication between their cavities and the lumen of the esophagus. The longitudinal chambers with their separating lamellae extend into these pouches between the muscle and epithelial layers for a distance which varies in the different species. Ultimately the cavities of the chambers open into the pouch cavities and a definite communication is established. In one species, and in only one of those commonly studied, *Lumbricus terrestris,* in each of the two somites next posterior to the pouches there are paired lateral swellings of the chambered wall which superficially resemble the pouches in somite 10 in size and form. This results in the presence of three pairs of lateral expansions of the esophageal tube which superficially resemble each other somewhat, and have led to the very common statements concerning three pairs of glands.

These paired inflations of the esophagus are in somites 10, 11, and 12. They are not separate glands, but are simply parts of one glandular structure, developed in the wall of the esophagus in somites 10 to 14. They certainly are not three pairs of pouches or diverticula opening into the esophagus as often stated. Marshall and Hurst's Zoology and a few other text-books that have adopted the statements contained in it are most nearly correct in their statements concerning the gland or glands, but make no mention of the continuation of the gland development in somites posterior to the 12th somite.

We will now consider some of the more common errors found in the text-book statements concerning this part of the worm. A new text-book which appeared in 1923 states that the esophagus begins in the "6th segment and continues posteriorly as a thin-walled, undifferentiated tube to the 14th segment where it connects with the crop

and gizzard. Three pairs of calciferous glands open into the esophagus near its posterior end." We have seen that the so called glands are merely parts of a highly differentiated wall, and furthermore that instead of the three pairs alike opening into the esophagus only one pair has such direct openings. In this book "The Common Earthworm" is described without any specific name, but the statement is made that the clitellum is on somites 28 to 35, from which it is evident that the author was writing about an earthworm altogether different from *Lumbricus terrestris*, in which the clitellum is on somites 32 to 37, and one in which there is but one pair of conspicuous enlargements of the esophagus instead of three pairs. The description of the reproductive organs also applies to *L. terrestis* rather than to a worm with the clitellum on somites 28 to 35.

The statements in such text-books concerning the calciferous glands in earthworms are more than a century behind the times, since they include less that is accurate and more that is inaccurate than is found in a paper by a European writer which appeared in 1820. I have recently examined 47 text-books in which earthworms are included in the list of animals studied. In 23 of them the calciferous glands are not discussed. Just 18 of the other 24 state, or imply, that the glands of the three pairs are alike. Only six mention differences of structure. Four give the correct location; five an incorrect location; and the other 15 are indefinite. Five of the 24 books describing the glands do not mention the number, and the other 19 all state that there are three pairs, even though the majority of them do not intimate that *L. terrestris* is the species of earthworm being discussed. The trouble is due to the fact that most authors do not base their statements on their own study of the animals nor on the published results of careful investigations, but chiefly on what they find in other text-books with an ancestry dating back into the previous century. A paper by Harrington in 1899 in the Journal of Morphology contained illustrations and information which supply a basis for correct statements concerning the anatomy of the glands in *L. terrestris*, but Hegner is the only author

that seems to have made use of it, and he has incorporated in his account one rather serious error. The general facts of position and form can be seen easily in a preparation made by splitting a well hardened specimen with a razor blade, in a frontal plane, about on a level with the upper rows of seta bundles. Serial sections are necessary for a detailed study of the anatomy.

Another topic in which I have been interested includes the text-book statements concerning the location of the nephridiopores. The nephridia are paired excretory organs of which one pair is found in each of all the somites, except a few at the anterior and posterior ends of the worm. Internally their ducts enter the body wall quite uniformly at the anterior margins of their respective somites, and slightly dorsad of the rows of ventral seta bundles. Approximately one half of the ducts pass directly through the body wall, and their external openings or nephridiopores are slightly dorsad of the rows of ventral seta bundles and hence on the surface of the ventral half of the worm. Since all the nephridial ducts enter the body wall at about the same level it seems natural to expect them to open externally at about the same level, but on the contrary approximately one half of the nephridial ducts follow a course in the body wall which leads dorsad for some distance and they emerge at the surface dorsad of the row of dorsal seta bundles at irregular distances. Marshall and Hurst described the location correctly more than 30 years ago and explained how the irregularity might be readily shown by stripping off pieces of the cuticula from slightly macerated specimens and placing them on slides, a very simple operation. Of 24 text-books making statements concerning the location of the nephridiopores, I find but three that have their statements correct. The others all assign a uniform location.

I will make brief reference to another feature of earthworm anatomy which is the occasion of numerous text-book errors. It involves a part of the circulatory system. The dorsal vessel, posterior to the so-called hearts of which the posterior one is in the 11th somite, is a collecting vessel and receives blood from the body wall and

from the alimentary tract through branches of the vascular system in each of most of the somites. This blood flows anteriorly and is forced into the ventral vessel by the hearts. In the anterior dozen somites the dorsal vessel does not function as a collecting vessel. The ventral vessel is in general a distributing vessel and from it blood is distributed to the body wall and alimentary tract. In it the blood flows anteriorly in front of the hearts and posteriorly throughout the remainder of the body. It is a very common assumption by text-book authors that the dorsal vessel functions as a collecting vessel throughout its whole extent, which is not true. Two longitudinal vascular trunks lying one on each side of the alimentary canal, and joining the dorsal vessel at their posterior ends in the twelfth somite, act as the collecting vessels in the anterior somites in place of the dorsal vessel. Only seven of the text-books mentioned make any reference to these vessels, and only one of them makes reference to the posterior connections of these vessels with the dorsal vessel in somite 12. Very few of the authors seem to have known of a very useful paper on circulation in earthworms which appeared in The American Naturalist in 1902 and was prepared by Johnston and Johnson.

A NEW MUSHROOM

W. B. McDougall, University of Illinois

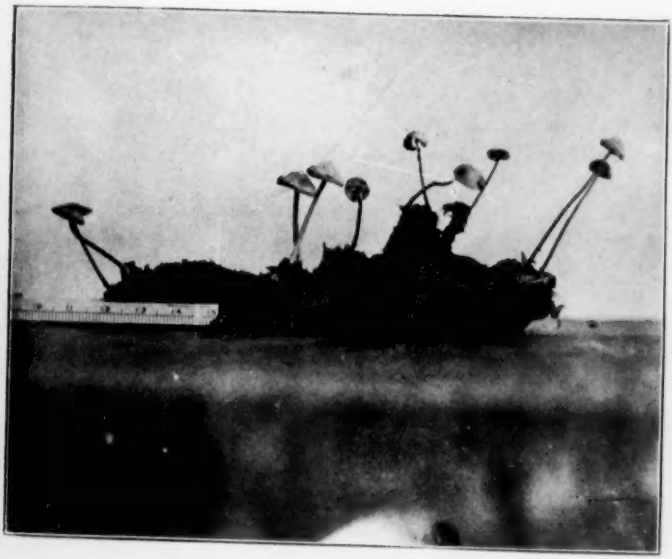
During the past few years I have been collecting in the University Woods near Urbana, Illinois, and occasionally at other places, a pretty little mushroom which very evidently belongs to the genus Marasmius but which so far as I have been able to learn is undescribed. (Fig. 1.) The plant is especially interesting because it always is attached to buried nuts. It is usually attached to walnuts or butternuts of the preceding year but occasionally it has been found attached to hickory nuts.

The substratum that the mushroom makes use of seems to be the nut shell rather than the meat. The meat of the nuts to which the mushrooms are attached looks normal and tastes normal. Sections of the meat washed in alcohol show under the microscope normal parenchyma cells full of crystaloid and globoid protein grains but with no sign of mycelium. On the other hand sections of a partly decayed half shell of a butternut to which a mushroom was attached showed mycelium present in the shell.

Because of the substratum on which this mushroom grows I am calling it Marasmius nucicola. A description follows:—

Marasmius nucicola n. sp.—Pileus 5-15 mm. broad, at first campanulate, becoming nearly plane or umbonate. Striate half way to the center, glabrous, reddish yellow to lemon yellow, fading to nearly white. Flesh thin, membranous. Gills adnate, moderately broad, not crowded, white or pale yellowish. Stem 3-4 cm. long, slender, smooth, reddish yellow to pale lemon yellowish, often darker above. Long, hairy, rooting base often 5-7 cm. long, extending and attached to a buried nut. Spores oval with a very short apiculus, 4-5 mu. x 8-9 mu., smooth, white. Odor none. Taste not pronounced. Edibility not tested. Cystidia numerous on edge of gills.

Under walnut and butternut trees in woods. Always attached to buried nuts of Juglans or occasionally of Carya. Often 3 or 4 sporophores are attached to the same nut. August to October.



LEGEND.

Fig. 1. Marasmius nucicola n. sp.

PRESENCE OF LIVING ORGANISMS IN LAKE ICE

SAMUEL EDDY, JAMES MILLIKIN UNIVERSITY

The object of these experiments and observations was to determine what forms of life were existing in the ice of Lake Decatur. Lake Decatur is an artificial Lake seven miles long and one-half mile wide, created by damming the Sangamon river. The depth of the water varied from a few inches to forty feet. The periods at which the materials were collected were during zero weather when the Lake was entirely frozen over. The thickness of the ice ranged from eight to twelve inches.

On January 7, two samples of ice and two samples of water from below the ice were collected. The ice was taken from the surface near the shore and from the center. Each sample was immediately placed in sterilized bottles containing sterilized hay infusion and plugged with cotton. The samples of water at a temperature of ½ degree Centigrade were taken from the holes from which the ice was cut. The samples were placed in similar bottles and under the same conditions. A sample of mud from near the shore was also treated in the same manner. In the cultures from the ice and hay infusions, observations were made January 23, January 28, and February 6. On all these dates various bacteria were common. The only other form of life observed was Chlamydomonas which was present in small numbers on January 23, but multipled rapidly enough to be common on the other observation dates. In the cultures from the hay infusion, and lake water or mud examined under the same conditions on the same days, Chlamydomonas, Urosomas, Chilomonas, Coleps, Pleuronema, Stilonichia and many other unidentified protozoa were observed.

On January 25, two samples of ice, four of water and two of mud were collected and treated the same as those collected January 7. Nutrient agar was substituted for the hay infusion. Observations were made January 31 and February 7. The results were practically the same. Chlamydomonas and bacteria were the only forms of life in the ice cultures. Chlamydomonas, Leucophrys, Para-

From the Department of Biology, the James Millikin University, No. 2.

mecium, Ameba, and other protozoa were common in the water and mud cultures.

On February 22, four samples of ice and two of water were collected and treated the same as before. Three cultures of sterilized lake water and nutrient agar were made at the same time and subjected to the same conditions in order to determine if infection from the air could account for any of the resulting forms. Observations on all these cultures were made February 27 and March 4. In the ice cultures, Chlamydomonas and bacteria appeared. In the water cultures, Chlamydomonas, Pleuromonas, Ameba, and other protozoa were common. In the sterilized lake water culture used as an additional check, no forms of life were present, indicating that the probability of the origin of any of these forms from the atmosphere was slight.

On February 7, four cultures of Chlamydomonas, containing also Paramecium, were frozen from twelve to twenty-four hours and then thawed. The cultures were kept isolated and were observed February 14. The only forms observed after thawing were Chlamydomonas and bacteria. These organisms were present in all four cultures. The Paramecium which were common before freezing never appeared after freezing and thawing.

In the eight samples of ice collected from Lake Decatur at three different dates, bacteria and Chlamydomonas seemed the only forms present. From the water just under the ice, many different protozoa were obtained. In all the cultures, except those of sterilized lake water, bacteria were observed, but were not regarded as of much significance as they easily withstand freezing and thawing. It seems that Chlamydomonas is the only form of protozoa in Lake Decatur able to survive freezing and thawing.

SOME SOUTHWESTERN LIMITS OF PLANTS IN INDIANA, ILLINOIS AND IOWA, WITH SUGGESTIONS ON THE SIGNIFICANCE OF THE PHENOMENA OBSERVED

H. C. Cowles, University of Chicago

(Paper not submitted for publication)

SOME OUTSTANDING FEATURES OF THE PLANT DISEASE SITUATION IN ILLINOIS DURING 1923

L. R. Tehon, State Natural History Survey, Urbana

The progress of plant disease infection, especially of crop plants, throughout the state, was kept under observation during the season of 1923 by the Natural History Survey's botanists. Their observations are reproduced in condensed form in this paper as a continuation of the papers presented at the two previous meetings of the Academy.

During the 1923 season plant diseases appeared in Illinois in their usual abundance and those attacking crop plants were responsible for large crop losses. The unusual weather conditions of the season favored the development of certain diseases, not usually very serious in our state, to the extent that they took on the appearance of severe epidemics.

WEATHER SUMMARY

While the mean temperature for the year 1923 was 1° above normal for the state, seasonal variations in temperature and precipitation in various parts of the state interfered with the usual routine of crop production. The snowfall was deficient in all parts of the state during January and February, leaving over-wintering crops exposed to the low temperatures recorded in February. Four months beginning with February had mean temperatures below normal and resulted in a backward spring which delayed the growth of winter wheat and the planting of corn. Precipitation was below normal north and west of the Illinois river, and generally above elsewhere, increasing from 27 inches in the northwest to 58 inches in the Ohio Valley.

Phenomena particularly favorable to plant disease development included the fact that 56 per cent of the year's precipitation occurred during the crop growing season. The number of cloudy days was greater only in 1915 and the number of days with rain was greater only in 1898 and 1915.

DISEASES OF FRUITS

Among Apple diseases, the development of Bitter Rot in epidemic form for the first time in nearly 20 years was the outstanding feature of the season. The epidemic ranged throughout the southern third of the state and the area of infestation was limited northward, with the exception of Macoupin county, by a line running east and west along the northern boundary of Clay county. The Black Rot disease, first found June 4 in Jackson county, was less prevalent than usual. Blister Canker was found in its usual abundance in Ben Davis orchards, and Blotch, our most serious apple disease, was found to be extending its range northward in commercial orchards. Apple rust occurred in its usual range in southern Illinois and along the Mississippi river to the Wisconsin border. Heavy infections of Fire Blight were reported on Jonathan, Transparent, Benoni, Wine Sap, and King David. Powdery Mildew, which requires a relatively dry season for its development, was seen once only. Scab appeared in greater amounts in western Illinois than in the south and central parts of the state.

Among the diseases of the Pear, Blight was as usual the most important. Brown Rot was seen only in Pike county and Leaf Blight only in Marion, Johnson and Pulaski counties. Scab was serious on both fruit and leaves in Champaign county. An unusual feature was the abundant development of Sooty Mold on pear leaves in southeastern Illinois following the attack of sucking insects.

On the Quince, Fire Blight appeared in its usual severity throughout the southern two-thirds of the state. Leaf Blight was equally severe but was limited to the southern half of the state.

Peach diseases were more severe than usual. The bacterial Shot Hole was abundant as far north as Bureau county and Brown Rot as far north as Champaign county. Leaf curl was the cause of severe defoliation through central Illinois in early spring, while Scab, rampant from spray failures, injured a considerable part of the crop in the south.

Plums suffered most severely from Brown Rot, which was most severe in the northern half of the state. Black Knot was prevalent in the southern half. Leaf Blight was more severe southward and was second only to brown rot in severity. A Leaf Curl of red plums, caused by *Exoascus mirabilis* Atk., was found in six counties. This disease appears to be increasing in abundance.

On Cherries, Brown Rot was especially abundant southward while Powdery Mildew was generally prevalent in central Illinois. Shot Hole was responsible for serious defoliation locally southward.

Grapes suffered to a greater degree than usual from Black Rot, and Bitter Rot was an important disease in Madison county. Downy Mildew was much worse than usual in the Mississippi and Illinois valleys, but Powdery Mildew was not reported.

Leaf Blight and Leaf Spot were both more prevalent than usual on Strawberries, and a root rot of unknown cause was prevalent throughout central Illinois, causing serious losses among the plants. Orange Rust appeared on Blackberries more commonly than usual and Cane Blight was serious in some commercial plantings on both Blackberries and Raspberries. Currants and Gooseberries suffered to some extent from Leaf Spot and the general attack of Gooseberry Anthracnose was serious locally in central Illinois.

DISEASES OF CEREAL CROPS

Leaf Rust of Wheat, usually the most important disease, was held in check by the low temperatures of early spring. The slow development of the crop, however, gave rise to the most general Stem-Rust infection in years. Loose Smut was less abundant than usual, while Stinking Smut became the most important source of loss, causing a crop reduction estimated at 6.4 per cent and a cash dockage in marketing the crop of more than $100,000.

The range of Flag Smut infestation was extended from the neighborhood of East St. Louis to include parts of nine counties, of which Hancock and Logan counties are the farthest north. Scab was unusually prevalent throughout the state. Anthracnose appeared for the first

time as a serious wheat disease. Its distribution appears limited to central Illinois where it was seen most commonly on hard winter varieties.

The Crown Rust of Oats was much less abundant than usual, although there were severe local outbreaks northward traceable in some cases to the presence of the Buckthorn in cultivation. Smut was more prevalent and occurred everywhere, with the exception of a few counties where preventive treatment is consistently used. Stem Rust was rare in the south but occurred throughout the state.

Barley suffered only slight Leaf Rust infections, but the loss from Loose Smut was rather large. The Stripe disease was very important in northern Illinois. On Rye, the Ergot infection was slight but Leaf Rust infection was prevalent and fairly severe. Scab was found only in Christian county. Stem Smut was prevalent in central Illinois where it caused some very severe losses in individual fields.

Rosen's Disease of Corn was found in Alexander county. Stewart's Disease was not of great importance but was much more general than usual. The Black Bundle disease appeared to have a general distribution and was an important source of loss. The range of the Brown Spot disease was extended northward to Carroll county and was much more abundant southward than usual.

VEGETABLE AND FIELD CROPS

The Angular Leaf Spot of Cucumber was found in the state for the first time and the Anthracnose disease appeared in considerable severity in Union county on this crop as well as on Canteloupes and Muskmelons. Watermelons suffered much less than usual from Wilt but the wet season was especially favorable to the development of Anthracnose which caused total losses in some districts.

Cabbage Yellows was less severe than usual, but more than the usual injury resulted from the great prevalence of Black Rot. A slight Club-root infection was seen in Cook county and Black Mold was very serious locally

in southern Illinois. Cauliflower also suffered severely from Black Rot.

On Tomatoes, Blossom-end Rot appeared locally and Early Blight was of general occurrence. Wilt was more serious than usual and Leaf Spot was as usual injurious to plants everywhere. Mosaic was seen only in Douglas and Effingham counties.

Potato Black Leg was seen in three scattered counties, Logan, Lawrence, and Monroe; and Curly Dwarf was found in several fields in Carroll county. Early Blight was especially prevalent in central Illinois while Scab appeared most serious southward.

DISEASE LOSSES

While the reduction in yield from the attack of plant diseases can not be accurately determined, it has been the custom for several years to estimate the losses in order to express in a concrete manner the importance of these diseases. The estimates shown in the following table indicate the importance ascribed to the diseases of some of our important crops.

ESTIMATED REDUCTION IN YIELDS* OF ILLINOIS CROPS IN 1923, DUE TO THE PRESENCE OF PLANT DISEASES

	Crop produced (bushels)	Per cent of reduction	Reduction in bushels	Value per bu.	Total value lost
Cereals					
Wheat	62,506,000	16.5	12,351,000	$0.94	$11,609,000
Oats	135,100,000	8.5	12,500,000	0.39	4,875,000
Barley	6,612,000	5.5	384,000	0.58	222,000
Rye	3,450,000	3.5	125,000	0.75	93,000
Corn	337,312,000	20.5	87,102,000	0.65	56,616,000
Fruits					
Apple	7,370,000	15.0	1,300,000	1.15	1,495,000
Pear	307,000	7.0	23,000	0.94	21,000
Peach	675,000	8.0	58,000	2.64	153,000
Vegetables					
Potato	9,568,000	2.0	195,000	0.88	171,000
Sweet Potato	880,000	0.5	4,000	1.10	4,000
Totals					
Cereals	544,980,000	17.10	112,462,000		$73,415,000
Fruits	8,352,000	14.18	1,381,000		1,669,000
Vegetables	10,448,000	1.86	199,000		175,000
Total	563,780,000	16.82	114,042,000		$75,259,000

* Estimates of this kind have been made since 1917 in Illinois and elsewhere and have come to represent the crop reductions which trained and experienced workers believe to occur. Experiments, however, have indicated that in several instances the actual reductions greatly exceed the estimates.

The reduction in yield or the loss in money value can not be arrived at for many crops because of the lack of production and price statistics, but the reductions indicated in the table of 112,462,000 bushels of cereals valued at $73,415,000, of 1,381,000 bushels of fruits valued at $1,669,000, and of 199,000 bushels of vegetables valued at $175,000, the whole reduction totalling 114,042,000 bushels valued at $75,259,000, should be sufficient to impress upon every one the importance to agriculture in Illinois of undertaking a comprehensive and effective plant-disease-control program.

For the control of these diseases there are now available methods suitable to every crop. The disinfection of seed for seed-borne diseases among cereals and vegetables, the application of effective sprays for disease of fruits and vegetables, the eradication of alternate hosts for certain diseases of cereals and fruits, and the use of resistant varieties for diseases not amenable to other treatment are already used to a limited extent and have been found to be so generally effective that a more extensive use is greatly to be desired.

SOME NORTH AND SOUTH STREAM VALLEYS IN ILLINOIS AND THEIR VEGETATION

GEORGE D. FULLER, THE UNIVERSITY OF CHICAGO, AND C. J. TELFORD, ASSISTANT ILLINOIS STATE FORESTER

A considerable portion of Illinois is characterized by a relative level upland in which streams have cut channels and developed valleys of varying depth and width. This upland has its surface covered with rich dark colored soils described by Hopkins and his associates (1) as upland prairie soils under the designations "brown silt loam" and "black silt loam". These soils, consisting of loam formed principally from wind-blown material, have a depth of 3 to 5 feet and are covered with a grassland that has been well described by Sampson (2). In contrast, the stream valleys display soils characterized as timber soils by the Department of Soil Survey of the State Agricultural Experiment Station and by them called "yellow-gray silt loam", or "upland timber soil".

The distribution of these soils and the character of their vegetation in LaSalle County has been discussed previously by Fuller and Strausbaugh (3). In this county the prairie soils cover about 80 per cent of the surface, while the timber soils are limited to 12 per cent and are distributed irregularly along the streams. It has also been pointed out (4) that it seems to be certain that all these timber soils were covered originally with forests and that no forests have ever developed upon the prairie soils. In a further attempt to explain the distribution of vegetation, which here seems to be limited by soil conditions, Fuller (5) has emphasized the peculiarities of the distribution of such timber soil along north and south streams, and has shown that the strip on the east side of the stream is almost always the wider and that it often reaches twice the extent of that on the west bank. Such uneven distribution of timber soils and forest is well illustrated along Big Indian Creek, a tributary of the Fox River.

The explanation usually current for the narrower strip on the west side of the stream is that prairie fires in

their advance, driven by the prevailing westerly winds, make greater inroads upon the western edge of the forest than upon the eastern. Such destruction of trees and tree seedlings has been supposed to account for contraction of woodland areas along their western margins. In order to test the truth of this hypothesis and to discover whether the limits of the woodlands coincided with those of the slopes of the stream valley, through the courtesy of the State Forester, the junior author of this article ran a number of sectional lines or transects from west to east across the valleys of Little Indian Creek and Big Indian Creek in groups of two or three at intervals of from one-half mile to one mile. The position and extent of one group of three of these lines are shown in Fig. 1.

Along these lines the slope was determined accurately by levels and the results have been reduced to uniform scale, and a series of cross sections of the stream valleys have resulted that exhibit graphically the relative width and slope of the stream (Figs. 2, 3, 4). Each group of sections may be considered independently.

The sections A, B, and C across the valley of Little Indian Creek (Fig. 2) show that the valley is about 40 feet deep and that an average of the three sections gives a strip of timber soil (formerly covered with forest) 1000 yards wide on the west slope and a corresponding strip 2300 yards wide on the east slope. Further, the limits of the timber soil coincide exactly with the edge of the stream valley.

Another series of cross sections, D and E, from the upper part of Big Indian Creek (Fig. 3) show a valley 30 to 35 feet deep with slopes 600 yards wide on the west and 1600 yards wide on the east. Here, too, the angle of the western slope is decidedly greater than that of the eastern and the coincidence of the edge of the stream valley and the extent of the timber soil decidedly marked.

A third series, F. G, and H, come lower down the stream where Big Indian Creek has been augmented by the influx of the waters of the tributary, Little Indian Creek, and the waters have cut into the underlying rock (Fig. 4). Here the valley is about 80 feet deep, and the

average width is 1100 yards west of the stream and 2200 yards east, while again the coincidence of the soil and the timber is very close.

From these examinations of the contours of the stream valleys it is evident that the timber soil varies in its distribution with the varying slopes of the valleys. Indeed, a close examination of such timber soils makes it entirely clear that they are but the subsoils of the prairie silt loams where the latter have been removed by stream erosion. The comparative youth of the stream valleys has permitted little modification of the soil upon their slopes. It is therefore clear that if, as has been shown, the edge of the slope of the valleys marks the limit of the timber soil, and hence that of the original distribution of forest associations, prairie fires cannot be accepted as an adequate explanation of the narrowness of the wooded strip on the western slope of the stream. The cause must rather be sought in some factor that affects the slope of the stream valley and thus indirectly the distribution of timber soils and their forest cover.

Two such explanations seem possible, either one of which is more satisfactory than the fire theory. Geologists have found that on account of the rotation of the earth the waters of the north and south streams have been deflected somewhat to the west and have thus eroded the western bank more rapidly and given rise to valleys of unequal slope. It seems rather doubtful, however, if the volume of water in these small streams is sufficient to account for the very decided difference here seen in the slopes of the two sides of the valley. Examining somewhat similar small north and south streams on Long Island, Jennings (6) is inclined to reject such an explanation.

The other, and in the opinion of the writers, the more logical explanation is that the wind-borne soil material transported by the prevailing westerlies has been continually sifting in upon the western slopes and tending to fill up the western half of the stream valleys. This has at one and the same time checked erosion and caused the grassland to tend to invade the woodland. This explanation has been accepted by Jennings as the most

reasonable for similar erosion phenomena on Long Island, and it seems to apply with even greater force in a region where the upland soil consists, according to authorities quoted, of wind-blown loessial material. We may, therefore, conclude that the prevailing westerly winds are the factor limiting the westerly extent of the forest strips bordering north and south streams in Illinois, but they are effective through the transportation of soil material rather than through their influence on the advance of prairie fires.

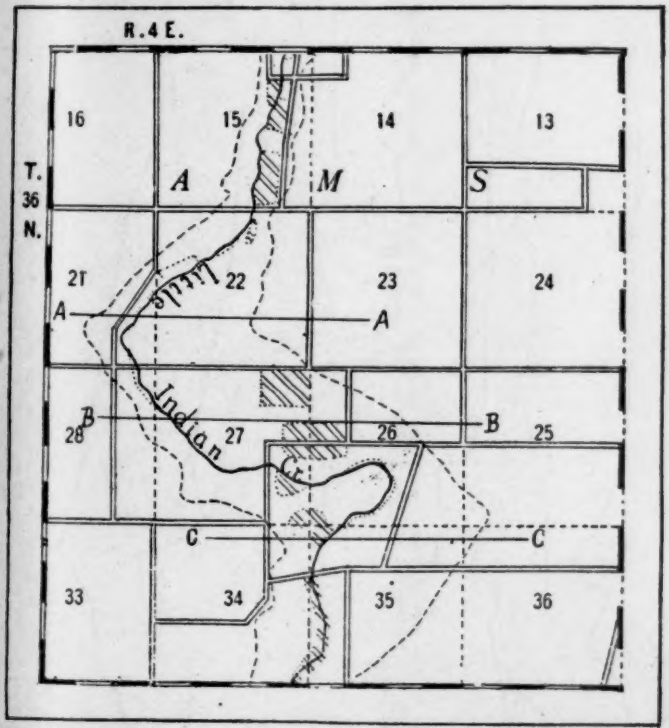


Fig. 1. Map of a portion of Little Indian Creek in Adams Township, LaSalle County, Ill., showing the original extent of the forests on the "upland timber soil," indicated by broken lines. On either side of the stream, the remnants of the forest, indicated by oblique hatchings and the transects A, B, and C, run from west to east across the stream valley.

LITERATURE CITED.

1. Hopkins, Cyril G. et al. La Salle County soils. Soil Report No. 5, Univ. Ill. Agri. Exper. Station, pp. 45. Maps. 1913
2. Sampson, Homer C. An ecological study of the prairie vegetation of Illinois. Bull. Ill. State Nat. Hist. Survey 13: 523-577. Pls. 48-77. Figs. 1-9. 1921.
3. Fuller, Geo. D. and Strausbaugh, P. D. On the forests of La Salle County, Illinois. Trans. Ill. Acad. Sci. 12: 246-272. Maps 1919.
4. Fuller, Geo. D. Soil as a limiting factor of the forests of La Salle County, Illinois. Trans. Ill. Acad. Sci. 12: 99-102. 1919.
5. Fuller, Geo. D. An edaphic limit to forests in the prairie region of Illinois. Ecology 4: 135-140. Fig. 3. 1923.
6. Jennings, O. E. Have the streams of Long Island been deflected by the earth's rotation? Science 55: 191. 1922.

Fig. 2. Sections of the stream valley made by transects A, B, and C. The vertical scale is about 25 times the horizontal, and the limits of the "upland timber soil" are shown by short vertical lines.

Fig. 3. Sections of the stream valley made by transects D and E. The vertical scale is about 25 times the horizontal, and the limits of the "upland timber soil" are shown by short vertical lines.

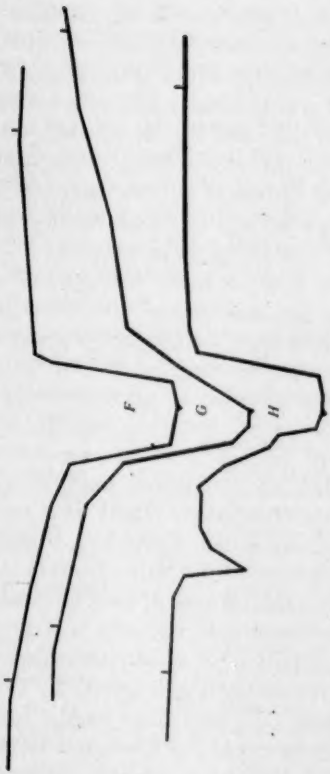


Fig. 4. Sections of the stream valley made by transects F, G, and H. The vertical scale is about 25 times the horizontal, and the limits of the "upland timber soil" are shown by short vertical lines.

PRELIMINARY CHECK LIST OF THE VASCULAR PLANTS OF THE ILLINOIS STATE PARK AT STARVED ROCK, LASALLE COUNTY

FRANK THONE, UNIVERSITY OF ARKANSAS, FAYETTEVILLE, ARK.

The establishment by the State of Illinois of the first of its state parks at Starved Rock, LaSalle County, has served to focus and intensify the interest of citizens of the state, and of the Middle West generally, in this region. Its great natural scenic beauty attracts tourists and holiday-seekers generally, and its connection with the labors and adventures of the early French explorers and missionaries gives it interest to students of history. Its great wealth of geological and botanical opportunity are tending to make it a point of pilgrimage for college and university classes bent on more serious and concentrated examination. In the interests of the latter groups it has seemed worth while to offer the accompanying check list of the vascular plants of Starved Rock State Park.

Up to the present, no list at all approaching completeness has been prepared for this region, although incidental mention of elements in the vegetation has been made in a number of ecological publications. A local naturalist of an earlier date, Huett (1), makes mention of the "plants of the bluffs along the Illinois River" in his "Natural History of LaSalle County", and in the same work reviews the efforts of two pioneers—who published their contributions in country newspapers. Cowles lists the more striking and characteristic species in the interesting bulletin on the Park issued by the Geographic Society of Chicago (2), and also makes incidental citations in another paper (3). Fuller and Strausbaugh (4) worked in the neighborhood of the Park, though their operations did not come within its boundaries. Kurz (5) carried on some studies in the Park. The present writer, who worked there during the spring and summer of 1921, has in print three papers on the ecology of the region (6, 7, 8) and another in anticipation.

The preliminary and provisional character of this list must be recognized. This is particularly true in regard

to the vernal flora. The list of aestival species is based on fairly thorough collections, one set of which has been deposited with the herbarium of the Field Museum of Natural History. Facilities for spring collecting, however, were unfortunately not so good, and the vernal species accordingly are based largely on field identifications and partial collections only. The writer also wishes frankly to disclaim any dogmatic certainty regarding a few of the more difficult groups; notable here are the sedges. Gray's Manual (seventh edition) was used throughout.

The writer's thanks are due to Professors Cowles and Fuller of the University of Chicago for encouragement, assistance, and generous provision of facilities; to Professor Conrad of Grinnell College for help in checking over identifications; and to the Illinois State Park Board for permission to collect in the Park.

Polypodiaceae
- Polypodium vulgare
- Adiantum pedatum
- Pteris aquilina
- Pellaea atropurpurea
- Asplenium filix-femina
- Polystichum acrostichoides
- Aspidium thelypteris
- Aspidium marginale
- Aspidium spinulosum
- Cystopteris bulbifera
- Cystopteris fragilis
- Woodsia ilvensis (*fide* Cowles)
- Onoclea sensibilis
- Onoclea struthiopteris

Osmundaceae
- Osmunda regalis
- Osmunda claytoniana
- Osmunda cinnamomea

Ophioglossaceae
- Botrychium virginianum

Equisetaceae
- Equisetum arvense
- Equisetum hyemale

Selaginellaceae
- Selaginella rupestris

Taxaceae
- Taxus canadensis

Pinaceae
- Pinus strobus
- Thuja occidentalis
- Juniperus virginiana

Typhaceae
- Typha latifolia

Alismaceae
- Sagittaria latifolia
- Alisma plantago-aquatica

Gramineae
- Andropogon scoparius
- Andropogon furcatus
- Panicum capillare
- Panicum scribnerianum
- Echinochloa crus-galli
- Setaria glauca
- Leersia virginica
- Muhlenbergia sylvatica
- Muhlenbergia mexicana
- Phleum pratense
- Agrostis hiemalis
- Cinna arundinacea
- Eragrostis trichodes
- Eragrostis pectinacea
- Poa pratensis
- Bromus purgens (?)
- Elymus australis (?)
- Elymus virginicus
- Hystrix patula
- Arundinaria tecta

Cyperaceae
- Scirpus atrovirens
- Carex stellulata
- Carex laxiflora
- Carex lupulina (?)
- Carex grayi

Araceae

Arisaema triphyllum
Arisaema dracontium
Symplocarpus foetidus

Commelinaceae

Tradescantia virginiana

Juncaceae

Juncus tenuis

Liliaceae

Uvularia grandiflora
Allium cernuum
Allium canadense
Erythronium albidum
Asparagus officinalis
Smilacina racemosa
Smilacina stellata
Maianthemum canadense
Polygonatum biflorum
Polygonatum commutatum
Trillium erectum
Trillium grandiflorum
Smilax herbacea
Smilax hispida

Dioscoreaceae

Dioscorea villosa

Iridaceae

Sisyrinchium albidum

Orchidaceae

Spiranthes cernua

Salicaceae

Salix nigra
Salix longifolia
Salix missouriensis
Populus tremuloides
Populus grandidentata
Populus deltoides

Juglandaçeae

Juglans cinerea
Juglans nigra
Carya ovata
Carya cordiformis

Betulaceae

Corylus americana
Ostrya virginiana
Carpinus caroliniana

Fagaceae

Quercus alba
Quercus macrocarpa
Quercus bicolor
Quercus rubra
Quercus velutina

Urticaceae

Ulmus fulva
Ulmus americana
Celtis occidentalis
Morus rubra
Laportea canadensis
Pilea pumila
Boehmeria cylindrica

Santalaceae

Comandra umbellata

Aristolochiaceae

Asarum canadense

Polygonaceae

Rumex crispus (?)
Rumex verticellatus
Rumex acetosella
Polygonum muhlenbergii
Polygonum pennsylvanicum
Polygonum acre
Polygonum persicaria
Polygonum hydropiperoides
Polygonum virginianum
Polygonum sagittatum
Polygonum dumetorium

Chenopodiaceae

Chenopodium hybridum
Chenopodium album

Nyctagineaceae

Oxybaphum nyctagineus

Caryophyllaceae

Cerastium arvense
Silene stellata

Portulacaceae

Claytonia virginica

Ranunculaceae

Ranunculus abortivus
Ranunculus recurvatus
Ranunculus septentrionalis
Thalictrum dioicum
Hepatica triloba
Hepatica acutiloba
Anemonella thalictroides
Anemone cylindrica
Anemone canadensis
Caltha palustris
Isopyrum biternatum
Aquilegia canadensis
Actaea alba

Anonaceae

Asimina triloba

Berberidaceae

Podophyllum peltatum

Lauraceae

Sasafras variifolium

Papaveraceae
Sanguinaria canadensis

Fumariaceae
Dicentra cucullaria
Dicentra canadensis

Cruciferae
Lepidium virginianum
Sisymbrium officinale
Erysimum asperum
Radicula palustris
Dentaria laciniata
Arabis lyrata

Crassulaceae
Penthorum sedoides

Saxifragaceae
Saxifraga pennsylvanica
Heuchera hispida
Mitella diphylla
Hydrangea arborescens
Ribes cynosbati
Ribes floridum

Hamamelidaceae
Hamamelis virginiana

Platanaceae
Platanus occidentalis

Rosaceae
Physocarpus opulifolius
Aruncus sylvester
Gillenia stipulata
Pyrus arbutifolia
Pyrus ioensis
Amelanchier canadensis
Crataegus spp.
Fragaria virginiana
Potentilla monspeliensis
Potentilla norvegica
Geum canadense
Rubus occidentalis
Agrimonia mollis
Agrimonia parviflora
Rosa blanda
Rosa humilis
Prunus serotina
Prunus virginiana

Leguminosae
Gymnocladus dioica
Gleditsia triacanthos
Cercis canadensis
Cassia chamaecrista
Baptisia leucantha
Trifolium pratense
Trifolium repens
Trifolium hybridum
Melilotus alba
Amorpha canescens
Amorpha fruticosa
Petalostemum candidum
Tephrosia virginica
Robinia pseudo-acacia
Desmodium grandiflorum
Desmodium nudiflorum
Desmodium bracteosum longifolium
Desmodium canadense
Desmodium sessilefolium
Lespedeza procumbens
Lespedeza virginica
Lespedeza capitata
Vicia americana
Strophostyles helvola
Amphicarpa pitcheri

Oxalidaceae
Oxalis violacea
Oxalis corniculata

Geraniaceae
Geranium maculatum

Rutaceae
Zanthoxylum americanum
Ptelea trifoliata

Polygalaceae
Polygala sanguinea

Euphorbiaceae
Euphorbia corrolata
Euphorbia dentata
Euphorbia heterophylla

Anacardiaceae
Rhus typhina
Rhus glabra
Rhus toxicodendron

Aquifoliaceae
Ilex verticellata
Nemopanthus mucronata

Celastraceae
Evonymus atropurpureus
Celastrus scandens

Staphyleaceae
Staphylea trifolia

Aceraceae
Acer saccharum
Acer saccharinum
Acer negundo

Balsaminaceae
Impatiens pallida
Impatiens biflora

Rhamnaceae
Ceanothus americanus

Vitaceae
Psedera quinquefolia
Vitis cordifolius (?)

Tiliaceae
Tilia americana

Malvaceae
Abutilon theophrasti
Hibicus militaris

Cistaceae
Helianthemum canadense

Violaceae
Viola pedata
Viola cucullata
Viola pubescens
Viola tricolor

Cactaceae
Opuntia rafinesquii

Lythraceae
Decodon verticellatus
Lythrum alatum

Onagraceae
Ludvigia alternifolia
Epilobium angustifolium
Epilobium coloratum
Oenothera biennis
Oenothera rhombipetala
Gaura biennis
Circaea lutetiana

Araliaceae
Aralia racemosa
Aralia nudicaulis
Panax quinquefolium

Umbelliferae
Erigenia bulbosa
Osmorhiza claytoni
Cicuta maculata
Cryptotaenia canadense
Taenidia integerrima
Pastinaca sativa
Heracleum lanatum

Cornaceae
Cornus stolonifera
Cornus paniculata

Ericaceae
Gaylussacia baccata
Vaccinium pennsylvanicum
Vaccinium canadense

Primulaceae
Steironema ciliatum
Dodacantheon meadia

Oleaceae
Fraxinus americana
Fraxinus nigra

Gentianaceae
Gentiana andrewsii

Apocynaceae
Apocynum androsaemifolium
Apocynum cannabinum

Asclepiadaceae
Ascepias incarnata
Asclepias phytolaccoides
Asclepias verticellata

Convolvulaceae
Convolvulus arvensis
Ipomea purpurea
Cscuta sp.

Polemoniaceae
Polemonium reptans
Phlox divaricata

Hydropyllaceae
Hydrophyllum appendiculatum
Nemophila marcrocalyx

Boraginaceae
Lappula virginiana
Cynoglossum officinale
Lithospermum gmelini
Mertensia virginica

Verbenaceae
Verbena urticaefolia
Verbena hastata
Verbena stricta
Lippia lanceolata

Labiateae
Teucrium canadense
Scutellaria lateriflora
Scutellaria versicolor
Agastache nepetoides
Nepeta cataria
Physostegia virginica
Prunella vulgaris
Leonurus cardiaca
Stachys palustris
Monarda fistulosa
Monarda punctata
Pycnanthemum flexuosum
Pycanthemum pilosum
Lycopus americanus
Mentha arvensis canadensis

Solanaceae
Solanum nigrum
Datura stramonium

Scrophulariaceae
Verbascum thapsus
Scrophularia leporella
Scrophularia marilandica
Chelone glabra
Mimulus ringens
Mimulus alatus
Veronica virginica
Gerardia grandiflora
Gerardia tenuifolia
Pedicularis lanceolata
Pedicularis canadensis

Acanthaceae
Ruellia ciliosa

Phrymaceae
Phryma leptostachya

Plantaginaceae
Plantago major

Rubiaceae
Galium aparine
Galium asprellum
Galium triflorum
Mitchella repens
Houstonia purpurea

Caprifoliaceae
Diervilla lonicera
Triosteum perfoliatum
Viburnum dentatum
Sambucus racemosa
Sambucus canadensis

Cucurbitaceae
Echinocystis lobata
Sicyos angulatus

Campanulaceae
Specularia perfoliata
Campanula americana
Campanula rotundifolia

Lobeliaceae
Lobelia syphilitica
Lobelia inflata

Compositae
Vernonia illinoensis
Eupatorium purpureum
Eupatorium serotinum
Eupatorium altissimum
Eupatorium perfoliatum
Eupatorium urticaefolium
Liatris scariosa
Solidago latifolia
Solidago hispida
Solidago uliginosa
Solidago ulmifolia
Solidago nemoralis
Solidago canadensis
Solidago rigida
Solidago graminifolia
Aster divaricatus
Aster furcatus
Aster novae-angliae
Aster azureus
Aster shortii
Aster drummondii
Aster laevis
Aster ericoides
Aster ericoides villosus
Aster ericoides platyphyllus
Aster multiflorus
Aster lateriflorus
Aster paniculatus
Aster linariifolius
Erigeron annuus
Erigeron canadensis
Antennaria plantiginifolia
Gnaphalium polycephalum
Polymnia canadensis
Silphium laciniatum
Silphium terebinthinaceum
Silphium integrifolium
Silphium perfoliatum
Ambrosia trifida
Ambrosia artemisiaefolia
Rudbeckia triloba
Rudbeckia subtomentosa
Rudbeckia hirta
Rudbeckia laciniata
Helianthus illinoensis
Helianthus grosseserratus
Helianthus divaricatus
Helianthus tuberosus
Actinomeris alternifolia
Coreopsis tripteris
Bidens frondosa
Bidens involucrata
Helenium autumnale
Achillea millefolium
Anthemis cotula
Chrysanthemum leucanthemum
Artemisia caudata
Erechtites hieracifolia
Cacalia atriplicifolia
Cacalia tuberosa
Senecio aureus
Arctium minus
Cirsium arvense
Taraxacum officinale
Lactuca canadensis
Lactuca ludoviciana
Lactuca hirsuta
Lactuca pulchella
Prenanthes alba
Hieracium longipilum
Hieracium canadense

LITERATURE CITED.

1. Huett, J. W: Natural history of La Salle County, Illinois. Part I. Botany. Ottawa, Ill. 1897.
2. Cowles, H. C.: Part III. Botany. In: Sauer, C. O., G. H. Cady and H. C. Cowles: Starved Rock State Park and its environs. Bulletin No. 6, The Geographic Society of Chicago. 1918.

3. Cowles, H. C.: The plant societies of Chicago and vicinity. Bulletin No. 2, The Geographic Society of Chicago. 1901.
4. Fuller, G. D., and P. D. Strausbaugh: On the forests of La Salle County, Illinois. Trans. Ill State Acad. Sci. 22:246-272. 1919.
5. Kurz, H.: Hydrogen ion concentration in relation to ecological factors. Bot. Gaz. 76:1-29. 1923.
6. Thone, F.: Ecological factors in region of Starved Rock, Illinois. Bot. Gaz. 74:345-368. 1922.
7. Thone, F.: Advantages of river canyons for ecological study. Trans. Ill. State Acad. Sci. 15:202-207. 1922.
8. Thone, F.: Evaporation rates on rock canyon walls. Bot. Gaz. 76: 419-424. 1923.

FOREST PRESERVATION—THE PATRIOT'S DUTY

E. M. North, DesPlaines

America is yet young. It is the springtime of her youth in spite of her spectacular development and the great inroads she has made upon her natural resources. We have made progress that easily outdoes any other nation in history, pioneering as we have done into new lands. We are still far enough this side of actual depletion of most of our natural resources to be able to arrest the usual course of waste to which every nation has fallen a prey. The United States is about to reap another great advantage from her educated citizenship in the promising conservation programs that are meeting with popular approval.

It is true that some of our natural resources are gone forever. In the absence of any conservation plan, the wild-pigeon is gone; the beaver is nearly extinct; the buffalo is maintained with difficulty in a few herds; natural gas, apparently inexhaustible at one time, is now but a memory in some sections of the country. Men here remember the six-or-eight-inch gas-wells in Indiana that were lighted for show day and night, sending a column of roaring flame a hundred feet high and turning darkness to daylight to the astonishment of beholders. They may also remember sitting in an Indianapolis hotel on a cold winter day with a gas-stove giving out a flame the size of a candle's. It is possible then to be recklessly and heedlessly destructive of wealth that belongs as much to the citizens of 2250 as of 1850.

For, after all, to whom does the land of a nation belong? The owners of a farm in one generation camp on it for a few brief years, take leave of life, and involuntarily surrender ownership to the succeeding generation. No man owns his piece of land, no matter how solemnly the Recorder of Deeds may officially declare it. It is to be the possession and the home of uncounted generations after him, who will come like himself, to camp on the spot, draw their sustenance from it for a few fretful years, and then move on in the great caravan of humans

that press ceaselessly over the Great Divide. It would seem quite evident that the Great Designer of this interesting orb never intended that any single generation should take a mowing-machine to the natural resources of any region on the face of the earth.

This has been done in some lands with some of their natural resources. China today is reaping a harvest of penury and famine and flood through the indiscriminate exploitation of her forests for many generations. The inspiration of her sages and religion makers has not been wise in this matter; their deity failed to reveal this vital failure to them. Their people perish, often a million a year, from floods that need not occur. One would expect this in a country where the people do not read or write, and where national life has not been developed in any real sense whatever. They are like the over enthusiastic youth at the circus who spends all his loose change for red-lemonade and peanuts and finds himself without car-fare at midnight, twenty miles from home. Before it is too late for our own young nation it is the part of a patriot to thrust the problem of conservation into the daily thought of his countrymen. The extent toward which forest depletion has been rapidly driving will make the average citizen rub his eyes and stare in amazement. As for our forest-resources, we are like a young man with all his front teeth out at twenty-five.

America once had inexhaustible forests over wide reaches of her territory—easily inexhaustible with any sort of early national inventory and planning. No section of this country outside of the great treeless plains needed ever to be a pauper begging for lumber. They had enough and to spare. But pioneering was done at fever-heat. Almost as by legerdemain the forests of whole states were cut away to such a degree that people can not today live upon millions of acres that once supported a thriving population. One can travel today in eastern states, in some regions for miles, and see only an occasional farm. The one time wealth-producing acres have been abandoned; farms that once had enough timber upon them to support a good-sized family today have only an occasional tree. In fact, all sections of the

United States except the far Northwest are wearing more and more the emaciated look of a hunger victim.

The Northeastern States, once rich in forests, are now hard put to it to run their huge paper pulp-mills, shipping in two-thirds of their supplies from Canada, and they are feeling much as did the Irishman who cut off the limb between himself and the tree. Already Canada has put an embargo on crown-forest shipments, and the paper-print factories are panicky lest export from private forests be also forbidden. Is it not humiliating to be an industrial suppliant at the feet of a British province for such a prime necessity as print-paper? Now some few attempts are being made in the East to remedy this matter by intelligent tree-farming, but it is too late to overtake the lost opportunity. What can we do if the Canadian supply fails us? Canada is not the one to worry about that. England with her serious housing scarcity, and her determined attempt at reforestation, is almost sure to call upon her loyal province over here to help her out, and an embargo of Canadian lumber-products is not at all improbable.

The great Northwest Territory from the Ohio to the Lakes was plentifully supplied with timber, almost an unbroken forest of noble hardwoods, when its doors were opened to the settlers who poured in like a horde of invaders to appropriate her natural resources. Restless, ambitious, energetic, resistless, they first laid the axe to the forests. Billions of feet of the finest lumber were fed to the Moloch of unregulated exploitation. Have you never heard men yet living tell how they cleared these forests for the domesticated plants of agriculture? The neighbors would gather upon invitation for a log-burning. The trees had been felled and partially trimmed; they dragged them into great piles as high as a house, and attaching cables, their horses in tandem drew them up inclined planes until they looked like grouped cottages and farm-buildings. Then the fire was applied, and respecting no aristocracy of species, quality or size, it consumed with lurid greediness black-walnuts, sugar, oak, poplar, elm and ash, often as much as six feet in diameter,

monarchs upon which Nature had spent two or three hundred years of architectural efforts.

Even where some of the timber was left standing, often when taking out the salable timber, the wood-cutters were entirely careless of the trees about them, and many younger trees were and are still being destroyed when the giant falling ruins a score of others about him. Unscientific and ruinous pasturing has trampled down the soft forest-earth until it is hard and often baked, very inhospitable to struggling seedlings that do their best tc preserve the species. Forest fires too have been very destructive, and even today the forests actually burned would equal a strip ten miles wide from New York City to Denver, annually consigned to destruction. Careless campers, hunters and automobilists are responsible for the largest percentage of losses from this cause. The U. S. Forestry Department expects to accomplish a very large annual saving, 1,000,000,000 cubic feet, and $17,000,000 worth, by effectively curbing this loss. In our own state of Illinois more than half the fire-loss is due to the railroads, wood-cutters and careless campers. It is not unusual to see the tell-tale scars left by a dozen successive campers who built their camp-fires among the roots of some lordly roadside elm that had gladdened the eye of a generation of admirers of beauty.

What is the result among us in the Central West? 90 per cent of the original forest is gone, and at very heavy cost for transportation, you and I and our needy neighbors are importing 47 per cent of our lumber from distant regions, some of it from the South, herself already in straits for some species, but mostly from the remote Northwest Pacific States. From kings to paupers! There is more reality in the term than is pleasant to recall. Members here who are familiar with the housing conditions in our great cities and their suburbs are well aware that thousands of our citizens are living in dwellings of about the size and quality of store-boxes, unsanitary, unfit for habitation, such as no farmer would think of housing his animals in, for he would be sure that pneumonia would destroy them. This is a national wrong. Good patriotism can not rest without bringing about a

change. America is too young a nation to be preparing a pauper class in any such numbers as these.

Even the South is beginning to realize that she has cut back her fingernails too close to the quick. Once the Southeast used to supply practically all the world's naval stores of tar, pitch, rosin, turpentine, etc., and she still claims to supply 85 per cent of it. But slowly and surely France is overtaking us with products from her artificial pine-forests under government supervision. We no longer have a monopoly on these products, and it seems probable that we must gradually say goodbye to a large percentage of it. Again the cause is found in the reckless handling of the patient pines that have suffered themselves to be vandalized by unscientific exploiters. From this same cause in other sections of the South other species are being so rapidly depleted that Florida citrus-growers are sending S. O. S. calls in every direction for crating for their fruits.

In the telling of the whole tale, volumes could be written by our Forest Department, but our time limits here are wisely narrow, and we can do little more than mention some of the main features. But before such a body as this it is worth any citizen's time if even but one more recruit is made in ten minutes for the policy of intelligent conservation of this valuable resource.

In the remaining minute or so it will be worth our while to hear the program of the U. S. Forestry Department, now drawn up in the form of a law under discussion in Congress under the name of the McNary Bill. This provides:

1. The initiation of a definite Forestry Policy, in which both the Nation and the States will bear an equal share of the responsibility both of oversight and financial support.

2. By bringing the nation to realize that it must no longer treat our forests as an inexhaustible resource, but that lumber must become a crop to be cultivated as wheat and corn are cultivated. This means additional educational facilities for teaching the new science of forest culture.

3. Legislation changing the present unfair tax-system that taxes growing forests that cannot yield any return, at the same rate as those acres beside them that are annually producing wealth.

These are all included in the McNary Bill, and any influence members may have for getting this bill through Congress can be turned to a service of intelligent patriotism in its behalf.

PAPERS ON CHEMISTRY AND PHYSICS

THE VARIATION OF PITCH OF THE NEW SINGING TUBE WITH LENGTH

CHAS. T. KNIPP AND A. J. MCMASTER, UNIVERSITY OF ILLINOIS

That the pitch of the new singing tube depends upon several factors, including the difference of temperature between the closed end and the remainder of the tube, the absolute temperature, and the linear dimensions of the tube has been known for several years. The relation between absolute temperature and pitch has been investigated,[1] and so also has the relation between pitch and density[2]; however, an exact and quantitative mathematical statement of the relations involved in the production of sound by heat by means of the new singing tube has not been offered. The object of the present investigation was to indicate in an experimental manner the variation of pitch with the external length of the tube.

With this aim in view, a tube was constructed of pyrex glass, of the form shown in Fig. 1. The dimensions of both the inner and outer tubes are given in Table I.

TABLE I

Tube No. 1.

Inner tube:	length	= 65.0 mm
	inside diameter	= 7.0 mm
	wall thickness	= 0.75 mm
Outer tube:	inside diameter	= 10.6 mm
	wall thickness	= 1.0 mm

The tube was then water-jacketed over its entire length to within 2 cm of the closed end, which was heated by means of a ring burner. The pitch of the tone emitted by the tube was measured by comparison with a tone variator. The tube was then removed from the jacket, and a portion of it (2 to 5 cm) cut off at the open end. The water jacket was shortened and replaced and the pitch again measured as before. This procedure was repeated until the outer tube was but a little longer than

[1] Phys. Rev., N. S., Vol. XV, p. 336.
[2] Phys. Rev., N. S., Vol. XXIII, p. 115.

the inner tube. The data taken for tube No. 1 are given in Table II.

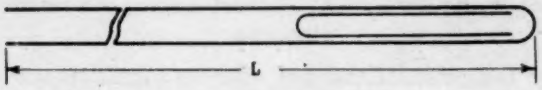


Fig. 1

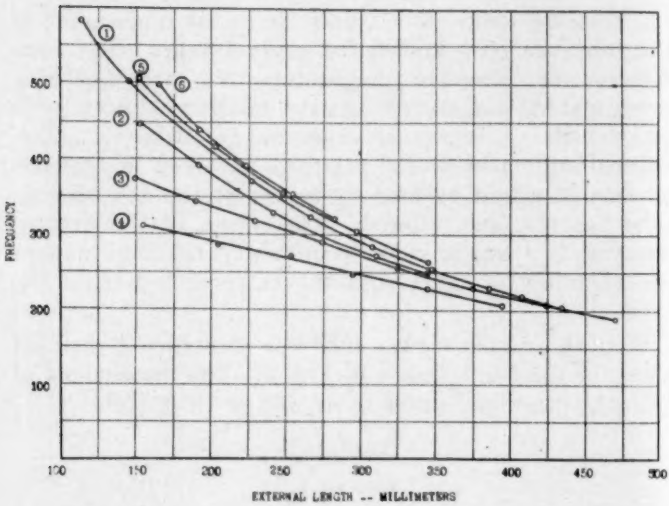


Fig. 2

TABLE II

Tube No. 1

External Length L	Frequency
434 mm	203
408	217
384	229
348	253
308	284
267	323
228	370
147	500
115	582

The variation of the pitch with the length of tube No. 1 is shown graphically by Curve 1, Fig. 2.

Other tubes were constructed in which the diameters of the inner and outer tubes, and the lengths of the inner

tubes were different. These tubes were jacketed and the pitch for various external lengths measured in the manner described. The results of these observations are also shown in Fig. 2. It is not possible to draw definite quantitative conclusions from the results obtained. The curves shown, however, indicate that the pitch not only depends upon the *absolute temperature*, but also that it varies according to a *definite law* involving the external length, and the other dimensions of the tube. The observed data all fall on smooth curves, which fact favors the possibility of such a law.

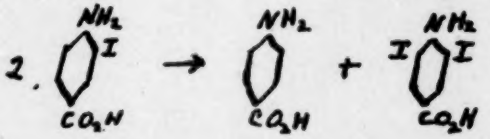
POSITIVE REACTIONS OF HALOGENS ATTACHED TO CARBON

BEN H. NICOLET, UNIVERSITY OF CHICAGO

When the halogen atoms of an organic halogen compound can be removed by hydrolysis, they are usually replaced by hydroxyl, and appear in the solution as halide ions. This is often expressed by calling these halogens negative. In a number of cases, however, the hydrolysis of halogen compounds takes a different course, resulting in the replacement of halogen by hydrogen, and the appearance of the halogen liberated as HOX or an equivalent form. This behavior is well described by calling such halogens "positive". In neither case is there any intention of implying that, in the original compound, the halogen was necessarily either negative or positive to a degree sufficient to produce measurable ionization[1].

In most, if not in all, of the cases in which the halogen is attached to an amino or imino nitrogen, or to oxygen, the halogen is positive; this has long been recognized, and even made the basis of quantitative determinations of such compounds. Positive halogen attached to carbon has been recognized in certain aliphatic compounds[2].

In the aromatic series, a considerable number of the iodo and bromo-compounds show evidence of containing positive halogen, and it is in general possible to predict which will show this behavior[3]. A striking example is 3-iodo-4-aminobenzoic acid, which, as observed by Wheeler and Liddle[4], undergoes the following reaction when heated "for a few minutes" with hydrochloric acid.



[1] Cf., for the use of this idea of polar valence in organic compounds, Stieglitz, J. Am. Chem. Soc. 44, 1293 (1922), and earlier papers; and Lewis, Valence and the Structure of atoms and Molecules (1923), particularly pp. 83 and 132.

[2] Nef, Ann. 308, 329 (1899); Howell with Noyes, J. Am. Chem. Soc. 4, 991 (1920); Macbeth and others, J. Chem. Soc. 119, 1356 (1921); 121, 892, 904, 1109, 1116, (1922).

[3] Nicolet, J. Am. Chem. Soc. 43, 2081 (1921).

[4] Am. Chem. J. 42, 453 (1909).

One notes that (a) an iodine has been removed, and replaced by hydrogen; and (b) the iodine thus removed retains the power of resubstituting in the bezene ring, a power which negative iodine does not have. A considerable amount of evidence collected since 1921 has confirmed the idea suggested at that time, that a somewhat similar behavior was to be expected on the part of any substance containing iodine in a position ortho- or para- to an amino- or to an hydroxyl-group, these two groups being among the most strongly negative known.

The rates at which iodine is removed under the conditions used (boiling with 10% hydrochloric acid, unless otherwise specified) vary greatly with the constitution of the substance examined. In many cases, too, resubstitution takes place less readily, and the iodine which then accumulates often oxidizes a portion of the substance. It is therefore often convenient, particularly when carrying out approximate quantitative measurements, to prevent both resubstitution and oxidation by the addition of a mild reducing agent. For this purpose stannous chloride has been used, and it may be emphasized that this has never as yet been found to act on any halogen which could not also be removed by acid alone.

From the relative stabilities of their inorganic compounds with oxygen and with hydrogen, it is obvious that iodine should show positive reactions more readily than bromine, and this in turn more readily than chlorine. This is found to be the case. When bromine occupies positions such as those specified for positive iodine, it is also removable under the same conditions, though some eight or ten times more slowly. The evidence for a similar reaction of chlorine, in the aromatic series, is indirect, though probably sufficiently definite, and for a single case only, namely, 2, 4, 6-triaminochlorobenzene.

More recent work has concerned itself with substances containing two amina- or hydroxyl-groups, and halogen ortho- or para- to at least one of them. Such halogens (bromine or iodine) are removed much more rapidly when the two negative groups are meta with respect to each other, and more slowly when these are otherwise

located. For instance, iodi-p-phenylenediamine lost iodine less rapidly than o-iodoaniline, while 2, 4-diamino-iodobenzene reacted more rapidly than either, as did also the corresponding iodoresorcinol.

It might be well to emphasize the fact that halogens not in favored positions show no sign of reacting under any of the conditions used. This is shown, for instance, by the fact that 2, 4, 5, 6-tetrabromo-m-dinitrobenzene, warmed with a stannous chloride and acid, loses three of its four bromines quantitatively, giving 1, 3-diamino-5-bromobenzene. One might choose an even more decisive case; 2-iodi-3,5-dibromo-4-aminotoluene, after refluxing for 8-10 hours with the same reagents, loses all of its bromine, without the formation of a detectible amount of iodide ion. The product, 2-iodo-4-aminotoluene, should not lose iodine if the considerations already advanced are correct.

A SIMPLE FORM OF C. T. R. WILSON'S ALPHA-RAY TRACK APPARATUS

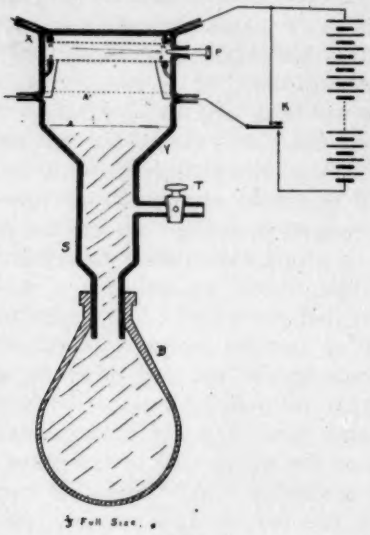
CHARLES T. KNIPP AND N. E. SOWERS, UNIVERSITY OF ILLINOIS

About two years ago considerable interest was excited among scientists by the appearance of the Shimizu modification of C. T. R. Wilson's cloud apparatus for making visible the tracks or traces of alpha particles thrown off from radioactive material. The essentials of an alpha-ray track apparatus are: (1) a closed chamber in which alternate compressions and expansions of the air may be made to take place, (2) means for setting up an electrostatic field across the chamber, (3) a suitable device for cutting off this field at the proper time with reference to the changes in volume inside the cylinder, and (4) a source of alpha-rays inside the chamber. In the Shimizu apparatus these essentials are elaborately and efficiently provided for by (1) a cylinder of metal and glass in which an airtight piston, whose length of stroke is adjustable, is moved up and down by an eccentric crank on a shaft rotated by hand or by a small motor, (2) a conducting film of moist gelatine carrying some $CuSO_4$ placed on the under side of the glass cover of the chamber and a similar film of gelatine carrying India ink placed on the top surface of the piston, between which surfaces an electrical potential may be applied, (3) a suitably shaped, adjustable commutator attached to and rotated by the crankshaft, so connected that it serves to apply and withdraw the electrostatic field between the gelatine films at the proper times with reference to the compression and expansions inside the cylinder, and (4) a trace of radioactive material carried on the tip of a metal pin which projects into the chamber through a ground-in, airtight bushing.

It occurred to the writers that the alpha-ray tracks might be effectively revealed by an exceedingly simple apparatus built along the lines of a modified cloud apparatus described by one of the authors a number of years ago[1], and which is at present being made by the

[1] Science III, Dec. 24, 1909, p. 930.

Central Scientific Company of Chicago, Illinois. The simplified form of the ray track apparatus was made entirely of glass,—of Pyrex glass. Fig. 1 shows a vertical section through the axis of the compression chamber and bulb, while Fig. 2 is a view from the top downward, as the observer would view the apparatus. Several ray tracks are indicated as issuing from the tip of the plug



½ Full Size.

Fig. 1

½ Full Size.

Fig. 2

P. In Fig 1 also are shown the electrical connections. The main body of the apparatus was made of a 150 cc Pyrex beaker, one being selected with a clear, smooth bottom so that anything taking place within the chamber could be seen easily and without distortion, the bottom

of the beaker forming the top of the chamber as shown in Fig. 1. The two electrostatic field plates MM and NN were made of coarse-mesh copper gauze and were held in place and kept flat by being wired to large rings made of small Pyrex glass rod. The upper ring with its plate MM was held in place against the top of the chamber simply by the tension of the two lead-in wires as shown. The lower ring with its plate NN was held in place by having three small legs of solid pyrex glass fused to the ring and the lower ends of these in turn fused to the walls of the chamber. Two only of these legs are indicated in the figure. Wires for electrical connection to the plates were carried into the chamber through capillary openings in the walls of the chamber as shown. In the experimental forms of the apparatus, these wires were held in place by filling the capillary tubes with "Bank of England" sealing wax. The plug P, on the tip of which the radioactive material was carried, was ground into a glass seat placed midway between the two plates. Finally, the mouth of the beaker was drawn down and sealed to a tube of smaller diameter, which was in turn drawn down to accommodate the stout walled rubber bulb used in actuating the apparatus. A small side branch tube, T, was provided for the introduction of water into the apparatus. The necessary electrical connections are shown in Fig. 1.

The procedure in operating the apparatus is, briefly, as follows: Fill the bulb and tube with water up to the level A. Insert the plug P. Connect the plate MM to, say, the positive pole of the source of DC potential and to the top contact of an ordinary two-contact tapping key, K, the tongue of the key being connected to the plate NN. Next connect the negative pole of the source of potential to the bottom contact of the key K. These connections are shown in Fig. 1. Then upon depressing the key the full potential of the source is applied across the plates, while upon releasing the key, the potential is removed and the plates are short-circuited together. For ease in observation the space between the plates MM and NN should be strongly illuminated. This may be done by means of a projection lantern, using a hori-

zontal slit to confine the light to the region between the plates.

To observe the ray-tracks, compress the bulb B with the hand until the water level reaches point A, Fig. 1. Considerable pressure will have to be exerted on the bulb to do this. At the same time depress the key K, throwing the potential across the plates MM, NN. Then release the bulb and the key at the same time, and if everything is working properly, ray tracks should be seen in the space between the plates. The function of the electrostatic field is to sweep away the ions formed by the impact of alpha-particles, except those that are formed just as the expansion takes place and which form the nuclei for the wisps or tails of cloud which are the alpha-ray tracks. By repeated trials, the proper amount of compression and the timing of the withdrawal of the electrostatic field with reference to the start of the expansion will be found which give the best results. With the field plates spaced about 1 cm, a potential of 110 volts across the plates has been found to give satisfactory results. Five to eight blocks of 22.5 volt Radio B batteries may be used for this purpose, or the voltage from a 110 volt DC supply circuit may be used.

The ray tracks produced by this apparatus are, for the most part, clear-cut and distinct. The unavoidable turbulency of the air in the chamber, due to the presence of the gauze plates and supporting rings, causes the tracks to move slightly from their initial positions. However, this drift of the tracks after they have formed is not serious when the extreme simplicity of the apparatus producing them is kept in mind. Another point in the operation of the apparatus is that after a dozen or so expansions have been made, the under side of the top surface of the chamber becomes clouded due to condensation of water droplets upon it. However, this surface may be cleared readily by tilting the apparatus from time to time so as to wet the entire top end of the chamber.

A NOTE ON THE EFFECT OF TEMPERATURE ON THE TRANSITION OF CALCITE TO ARAGONITE

R. EDMAN GREENFIELD, CHEMIST, STATE WATER SURVEY, URBANA.

In a study of the solubility of the different forms of calcium carbonate in carbon dioxide solutions and its bearing on corrosion problems, some things were noted which led to a little study on the condition of change of one form to another. The studies on solubility were carried out by shaking carbon dioxide solutions with solid calcium carbonate in a constant temperature bath until equilibrium was reached. Over a week was always allowed for this reaction.

Bicarbonate alkalinity, which represented the calcium carbonate dissolved, and free carbon dioxide were determined on the resultant solution. The results at any one temperature when plotted on ordinary coordinate paper gave a smooth graft of an exponential form. It was found that if they were plotted on logarithm paper they gave straight lines within the limit of error. Results for 0°, 20° and 65°C are shown in Fig. 1. It will be seen that the solubilities of both forms increase with temperature from 0° to 20° and that aragonite is appreciably more soluble than calcite at all times. At 25° and 35° results were obtained not much different from those at 20°; if any thing they were a little lower in both cases than were the 20° results. These results are not shown in Fig. 1. At 65° the two forms were about the same solubility and were lower than even the 0° calcite. At first these results were considered to indicate a transition temperature between the two forms of calcium carbonate, but later experiments on mixtures and a study of Johnson's[1] article shows this to be impossible. They may well indicate that the solubilities of the two forms become quite close at this temperature. This is supported by certain conductivity data and solu-

[1] J. Johnson, H. E. Merwith & Ed. Williamson, Am. J. Science, 4th ser. 41, 473 (1916).
Studies conditions of formation of different forms of calcium carbonate under different conditions.

bility products obtained by H. W. Foote[2]. Of course it is also possible that at this high temperature the unstable aragonite has partly changed to calcite and that the equilibrium is established with the more insoluble form. A specific gravity of the undissolved residue was run, but the results were not conclusive as the sample had not been ground fine enough and a true specific gravity was not obtained.

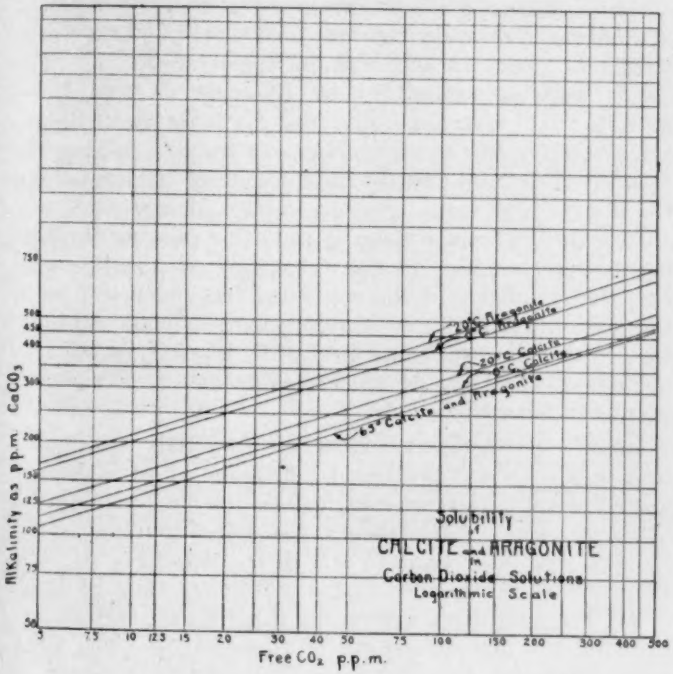
Fifty percent mixtures of aragonite and calcite were ground together, covered with water containing carbon dioxide and exposed to various temperatures. These mixtures were allowed to react one week when they were ground and the specific gravity determined. Temperatures of 20°, 37°, 65° and 100° were used. The change in specific gravity in every case indicated that the aragonite was being changed quite rapidly to calcite and that the reaction was more rapid at 65° than at 25° and 37°. The specific gravity determinations of the material exposed to 100° were not very concordant and no very definite conclusions could be drawn. This rapid change is contrary to most of Johnson's[1] findings.

Certain of the samples which were allowed to react at 65°C cemented firmly together to form a mass which was quite strong and which showed rather large crystals of calcite mixed in a matrix of small crystals. Samples exposed to other temperatures, while they became much more granular than the original material, did not cement together. The samples which were finely ground did not form as strong a material as that which was more coarsely ground. The condition of packing seemed also to have some effect upon the strength of the material. An attempt was made to form this cemented material by the use of ground marble and the aragonite from ground oyster shell. This material recrystallized into a more granular form but did not cement together.

This formation of a cemented material, using as a binder only a more unstable crystalline modification,

[2] H. W. Foote, Zeitshr. Physikal. Chemie, 33, 740 (1900) Uberdie Physikalish Chem. Beziechungen Zwischen Aragonit and calcit.
Showed by oxalate reaction and conductivity experiments that the solubility of calcite and aragonite approached each other with increasing temperature worked from 8° to 59° also show increase and then decrease. Aragonite at 50° still considerably higher than calcite.

may at times have been operative in nature, and might, if suitable material were available and if proper conditions of temperature, concentration of solution and state of subdivision were worked out, be of importance practically.



THE MOLECULAR SPECTRUM OF AMMONIA

B. J. Spence, Northwestern University

Preliminary Report

A number of years ago it was found that hydrogen chloride showed a double branched absorption band at a wavelength of approximately 45,000 A. U. This wavelength is found in the near infra-red spectrum. The bands were accounted for by Bjerrum (Nernst Festschrift, 1911) assuming that the diatomic molecule rotated about a line at right angles to the line joining the atomic centers and that the atomic centers vibrated along the line joining them. Such a system of molecules will absorb energy from a beam of radiation passing through them corresponding to the frequency of rotation and also the frequency of the combined frequencies of rotation and vibration. The double branched band will have frequencies corresponding to $f_v \pm f_r$, where f_v is the frequency of vibration of the molecule and f_r is the frequency of rotation.

Later experiments revealed the fact that the double branched band was not simple but made up of a number of fine bands. Bjerrum modified his theory involving the quantum theory. His theory was not altogether satisfactory, and later Lenz (Verh. d. D. Phys. Ges. 31, 632, 1919) following the idea of the stationary state of Bohr in his atomic theory arrived at a more satisfactory expression for the wavelength of these bands. The Lenz theory assumes that the molecules exist in a series of stationary states in regard to rotation and vibration, and that energy is emitted or absorbed during a transition between stationary states. Lenz's expression for the frequency of the emitted or absorbed radiation is

$$f = nf_o + \frac{h}{8\pi^2 I} \pm \frac{mh}{4\pi^2 I}$$

where f and f_o are the frequencies of the absorbed radiation and the atomic vibration frequency respectively, h is the Planck constant, I the moment of inertia of the molecule and m and n are small integers characterizing

the stationary states of rotation and vibration respectively.

The interpretation of the above expression is interesting. When the molecule is in the state characterized by the quantum numbers $n = m = 0$, it has no energy of vibration and of rotation. When a change occurs during absorption of energy such that $n = m = 1$, the frequency of the absorbed radiation is given by

$$f = f_0 + \frac{h}{8\pi^2 I}$$

So far this so called zero branch of the curve has never been observed, as far as the writer is aware. If the molecule is in the stationary state characterized by $n = 0$, and $m = 1$, then a transition to $n = 1$, and $m = 2$ gives rise to an absorbed radiation of frequency

$$f = f_0 + \frac{h}{8\pi^2 I} \pm \frac{h}{4\pi^2 I}$$

This expression indicates two bands, one on each side of the above zero branch. If now we allow the change from $n = 0$ to $n = 1$, and $m = 2$ to $m = 3$, and so on, we have a series of equidistant bands which approximate the experimental values fairly well. Experimentally these bands are not equidistant. The above theory was developed assuming an independence of m and n, or that the moment of inertia of the molecule is independent of the angular velocity. By making the necessary modifications with this point in mind an extremely satisfactory theory is developed which accounts for the facts very well.

The above theory was developed for the diatomic molecule. No theory exists for the polyatomic molecule. However, double branched absorption bands with the fine structure have been observed for polyatomic molecules. Their characteristics are, in the main, similar to those of the diatomic molecule.

In an investigation to bring to light other examples of these double branched absorption bands it was found that ammonia gas showed a serrated double band with a zero branch at 30,000 A. U. The investigation was carried on with an infra-red grating spectrometer, using a

radiometer as the receiving instrument. The grating was one of 2500 lines per inch and had a ruled surface 2 x 2 inches. A cell 10 cm. long with mica windows was so arranged before the slit of the spectrometer that it could be moved in or out of the beam of light brought to focus on the slit. Such an arrangement made it possible to determine the per cent absorption. The bands as observed for ammonia are not equally spaced, the wavelength interval between them increasing from about 140 A. U. on the short wave side of the band to 200 A. U. on the long wave side. In addition to the system of narrow bands a deep band was found at 299,000 A. U. which corresponds to the transition of n-— m = O to n — m — 1 as indicated above. This appears to be the first substance found to show the zero branch of the double absorption band. Eight of the narrow bands were found on each side the zero branch. Inasmuch as the grating used in the investigation was a 2500 line per inch grating it did not have sufficient resolving power to make accurate quantitative determinations possible. It is planned to examine these bands under larger resolving power.

The frequency difference between the narrow bands is given from the expression of Lenz as

$$df = \frac{h}{4\pi^2 I}$$

From this expression it is possible to get an estimate of the moment of inertia of the ammonia molecule. Substituting wavelengths in the expression and solving for I we have

$$I = \frac{h\lambda^2}{4\pi^2 c d\lambda}$$

where c is the velocity of light, λ the wavelength of a band and $d\lambda$ the difference of wavelengths between two bands. Making the substitutions, we find 2.8×10^{-40} gm. cm^2 as the moment of inertia of the ammonia molecule.

Northwestern University
May 4, 1924.

A STUDY OF THE EFFECT OF METALS IN CONTACT WITH SOLUTIONS OF SILVER HALIDES IN VARIOUS SOLVENTS

J. H. Ransom and D. W. Hanson, James Millikin University

PRELIMINARY PAPER

During the performance of an experiment by a class of students large quantities of a very dilute solution of silver salts were produced, from which, both for economic reasons and for its effect on the student, it was desired to recover the silver. It occurred to one of the authors that the easiest and most direct way to recover the silver was to convert it into chloride, dissolve this in some solvent like ammonia, and precipitate the silver by treatment with some metal like iron or zinc. Whether metals would precipitate silver from such solutions was not known and a search through the available literature did not indicate that the experiment had ever been tried.

When silver chloride is dissolved in ammonia it is believed that a complex positive ion results which contains both silver and ammonia, $Ag(NH_3)_2$. Since more than the equivalent amount of ammonia is necessary to produce solution it is probable that this positive ion is in equilibrium with the silver ion, the concentration of the latter ion decreasing with the increase in concentration of free ammonia. In any such solution, however, there might be enough silver ions so that in contact with metals whose solution tension was greater than that of silver ions the latter might be discharged and the silver deposited. A preliminary trial with such a solution gave a gray powder appearing somewhat metallic.

The solutions of silver salts, left over from the students' experiment, were collected and the silver precipitated by an excess of hydrochloric acid. After washing the silver chloride it was dissolved in rather concentrated ammonia, making a nearly saturated solution. To this was added granulated zinc. Almost immediately the gray deposit formed, together with some gas, probably hydrogen, and towards the end of the experiment

there were formed beautiful silver-white metallic crystals. Much of the gray powder was rather soft and malleable and when rubbed gave a metallic luster. Always there was a larger or smaller amount insoluble in dilute nitric acid, and this appeared to be silver chloride which had been affected by light. After some hours only the smallest traces of silver chloride remained in the solution.

These results were so encouraging that it was felt to be worth while to study the effect of various metals on solutions of the halides of silver, not only in ammonia solutions but in other solvents, especially in the "hypo" of the photographer. It is known that large quantities of the spent "hypo" liquors are discarded without the recovery of the silver contained in them, thus involving a great economic loss of silver as well as of "hypo". While a method is in use for the recovery of the silver it is felt by some photographers that it is more trouble than it is worth and the use of the recovered "hypo", if such it is, is not undertaken because of its possible injurious effect on the pictures.

When the silver halides, silver bromide especially, is dissolved in "hypo", sodium silver thiosulphate is formed. The solution may contain silver ions and the fact, as we show in this paper, that metals cause a deposition of the silver in a very pure condition is evidence that such is the case.

At this point the investigation was taken up by the junior author. The results, while only of a preliminary nature, are interesting, and we hope to extend the scope of the work at an early date.

After most of the results, here reported, were secured, there appeared in Chemical Abstracts, page 1094, (April, 1924) an abstract of an article in Chemische Zeitung by A. Steigmann, describing "A New Method of Precipitating Silver and Gold." In his method the solution of silver halide in "hypo" is treated with sodium hyposulphite $Na_2S_2O_4$, in the presence of soda which reacts with the sulphur dioxide produced during the chemical action. The abstract states that the fixing bath can be regenerated five or six times, but he recommends only

three times. Since the hyposulphite is usually made by reduction of the sulphite with zinc, and since soda must be used to neutralize the sulphur dioxide which is converted into sulphite and this in acid solution, in which the "hypo" is always used, produces sulphur dioxide which might act in an injurious way upon the picture, it seems a more direct and better method to use the zinc directly with the "hypo" in recovering the silver. This would be especially true if, as seems evident from our results, the hypo is as good and safe a fixing agent after treatment with the zinc as when freshly made.

In order to study in a more nearly quantitative way the action of several metals on solutions of silver chloride in ammonia, a nearly saturated solution of the chloride was made and one-half of it was diluted with an equal volume of distilled water. In separate portions of both the concentrated and dilute solutions were placed weighed amounts of the metals, zinc, aluminum, copper and iron and then these were kept in a dark room until all the silver had been precipitated. Before the metals were introduced their surfaces were well cleaned. With all the metals except iron precipitation of silver began at once and all the silver had left the solution within twenty-four hours (the first test was made at the end of this time). In the case of iron in the dilute solution the action had started only slightly at the end of the first hour and was complete only after forty-eight hours. In the concentrated solution the iron remained perfectly bright for the first day, and not a trace of silver had deposited. On being brought into the light, however, action began within fifteen minutes and seemed to continue after it had been replaced in a dark room. When the action had become complete the metals were removed, cleaned and weighed, and the precipitate treated with quite dilute nitric acid. In the case of zinc quite a large amount of material was not dissolved in the acid and appeared like darkened silver chloride. With the other metals only a trace of material was found to be insoluble. In the case of zinc it was found that 54% more went into solution than was equivalent to the silver formed. This might be anticipated from the fact that

water acts slowly on zinc to form the hydroxide. In the case of the other metals the excess loss was not determined.

Since the recovery of silver from "hypo" fixing baths is of commercial importance, most of the time was spent in its study. For this purpose a spent "hypo" solution was obtained from a local photographer. Before using this solution, however, preliminary experiments were performed with a fairly concentrated solution of silver chloride in sodium thiosulphate solution. The method used followed very closely that with ammonia solutions, using the same metals. With all of the metals it was found that the precipitation of silver began very slowly, only after two or more hours, and that it proceeded regularly to completion. With iron the end was reached only after forty-eight hours, but with the others twenty-four were all that was needed. Only slight traces of the precipitate were insoluble in dilute nitric acid. In the case of copper the silver deposited as a smooth layer upon the surface of the copper sheets; with the other metals the silver deposited very smoothly on the glass walls of the containing vessels, forming a mirror more or less perfect.

After this preliminary experiment a liter of the spent liquor, mentioned above, was treated with small rectangular chunks of pure zinc lying at the bottom of the flask. The silver slowly deposited as a mirror on the walls. About four grams of silver were deposited for three grams of zinc disappearing into the solution. This is far less silver than is theoretically possible (3.3 :1), but by using a larger surface of zinc suspended in the solution and by stirring the solution it is believed the amount might be increased nearly to the theoretical.

After the silver had become completely precipitated from the spent liquor a part of it was treated with sodium carbonate to separate the carbonate of zinc. After filtration of the carbonate it was found that the slightly acidified solution (with acetic acid) dissolved 62 grams of silver chloride per liter. The part of the silver-free solution from which the zinc had not been removed was found to dissolve 70 grams of silver chloride per liter.

This would indicate that the zinc salt in the solution had no injurious effect on the solubility of the silver halides, but rather improved it slightly.

In order to test the qualities of the treated "hypo" as a fixing agent the solution from which the zinc had been removed as well as that containing this metal was submitted to an expert student photographer for use in his fixing bath. He reported that both solutions worked in a perfectly normal manner, and that he could observe no decrease in efficiency as compared with the ordinary solution and no difference in the quality of the product.

It is planned to continue the investigation along several related lines and to the end of making the process a commercial success.

RECENT DEVELOPMENTS IN PHOTOCHEMISTRY

W. Albert Noyes, Jr., University of Chicago

The advent of the quantum theory has given us a means of applying some of the principles of thermodynamics to photochemical reactions. According to this theory, the energy of frequency ν incident upon a given system is necessarily some multiple of an energy unit, $h\nu$. The Bohr theory of atomic structure has successfully applied this idea to the spectrum lines of hydrogen and to X-ray data. According to this theory there are several possible "energy states" or "stationary states" for an atom. When the atom is in its normal state it does not radiate energy, but if energy is added to the atomic system either by electron impact or by radiation, the total energy of the system is now greater than for the normal atom by a definite amount. This energy may be represented by E. If now the atom returns to its original energy state, light of frequency given by the simple equation $E = h\nu$ is radiated, where h is Planck's constant.

Several attempts have been made to apply the ideas of the quantum theory to photochemical processes. Einstein[1] has derived a photochemical equivalence law, which, briefly stated, equates the radiant energy necessary to cause a mol of substance to react to the heat of reaction

$$\triangle H = Nh\nu$$

In the case of a system A′ capable of changing by the action of radiation of frequency ν into a system A′, radiation of frequency ν' being re-emitted in the process according to the scheme

$$A + h\nu \longrightarrow A' + h\nu'$$

then the heat of reaction would be given by the expression

$$\triangle H = Nh(\nu - \nu')$$

It should be noted that radiation of frequency ν' would cause the reverse reaction to take place if it were allowed to act on the system A′.

[1] Einstein, Annalen der Physik, 37, 832 (1912).

One other important attempt has been made to apply the quantum hypothesis to photochemical processes. Perrin[2] has proposed a theory which has been discussed in detail and modified to a certain extent by Tolman[3]. The classical Arrhenius equation

$$\frac{d \ln k}{d T} = \frac{E}{R T^2}$$

connects the constant in the equation for a monomolecular reaction

$$\frac{d x}{d t} = k(A-x)$$

with a quantity E which has the dimensions of energy. Perrin states that this term represents an energy of "activation", and writes $E = Nh\nu$. Thus a molecule might absorb an amount of energy $h\nu$ and subsequently either decompose or return to its original state. This formula has been applied to the decomposition of nitrogen pentoxide with great care by Daniels and Johnston[4] and roughly to the decomposition of solid oxalic acid[5]. In neither of these cases was the formula found to agree with the experimental facts.

It is obvious, of course, that an idea such as that proposed by Perrin could at best hold true in an ideal case. For the ordinary photographic action of light on the silver halides all wave lengths of light seem to be active from the red end of the spectrum to hard X-rays, a fact which could not be explained by Perrin's hypothesis. Berthelot[6] has suggested that the effect of radiation would increase with increase in frequency according to an exponential law, in much the same manner that the rates of thermal reactions increase with the temperature. In the case of the decomposition of a crystalline body by the action of radiation, it would seem that Perrin's formula should fail for the following reasons[7]: a molecule in a crystal lattice is held to the other mole-

[2] Perrin, Annales de Physique, *11*, 5 (1919).
[3] Tolman, Journ. Amer. Chem. Soc., *42*, 2506 (1920); *45*, 2285 (1923).
[4] Daniels and Johnston, Journ. Amer. Chem. Soc., *43*, 72 (1921).
[5] Noyes and Kouperman, ibid., *45*, 1398 (1923).
[6] Berthelot, Bull. de la Soc. chimique, *35*, 241 (1924). This article sums up many of Berthelot's views.
[7] Noyes, Comptes Rendus, *176*, 1468 (1923).

cules in the lattice by definite forces. A certain amount of energy must be added, therefore, in addition to the energy necessary to decompose a given molecule, in order to separate it from its fellows. Moreover, if present ideas of molecular structure are accepted, the action of light may be to set up vibrations of the atoms with reference to each other, or to cause a separation to a given distance of an electron. According to Perrin's theory the molecule would either decompose or return to its initial state. It would seem that the probability of decomposition would depend on the extent of the separation. Bearing this in mind, a formula analagous to that for the photoelectric effect would be obtained in which the rate of reaction is a linear function of the frequency

$$\frac{dx}{dt} = k\,I\,h(\nu - \nu_0)$$

In this formula the rate is assumed to be proportional to the intensity of the radiation, I, in the same manner as in most of the other theories.

The most general fallacy in reasoning connected with photochemical processes seems to be in making the assumption that one general theory can be found which will account for all reactions affected by radiation. It is well known that a catalyst will not cause a reaction to take place unless the reaction has a *tendency* to take place without the catalyst. In other words if a reaction leads to a decrease in *free energy*, as in the combination of hydrogen and nitrogen to form ammonia, a proper catalyst should greatly increase the rate of reaction, even though the rate of reaction is immeasurably slow under ordinary conditions. On the other hand if a reaction involves an increase in free energy, as in the combination of nitrogen and oxygen to form nitrogen dioxide, the mere use of a catalyst will not cause the reaction to take place. In the case of photochemical reactions, it seems that a similar distinction should be made.

Bodenstein[8] has classified photochemical reactions as

[8] Bodenstein, Zeit. phys. Chem., 85, 333 (1913). For a good summary see Lind, The Chemical Effects of Alpha Particles and Electrons, The Chemical Catalog Company, 1921.

either "primary" or "secondary". For "primary" light reactions the number of molecules reacting per quantum absorbed is either one or some small number. In this series of reactions the free energy change is either positive or very slightly negative (See Table I) for those reactions for which the free energy change is known. It seems probable that this could be stated as a general law.

TABLE I.

Primary Light Reactions (Bodenstein)

$2\ HI = H_2 + I_2$	;	$\Delta F°_{298} = -630$
$3\ O_2 = 2\ O_3$	;	$= +64800$
$2\ NH_3 = N_2 + 3\ H_2$	;	$= +7820$
$2\ H_2O = 2\ H_2 + O_2$	;	$= +109014$
$S\lambda = S\mu$	;	-1 (?)

In the case of "secondary" light reactions, one quantum causes a large number of molecules to react. These reactions are almost always those which involve a large decrease in free energy, and the light seems more to play the role of a catalyst.

TABLE II.

Secondary Light Reactions (Bodenstein)

$H_2 + Cl_2 = 2\ HCl$	;	$\Delta F°_{298} = -45384$
$2\ O_3 = 3\ O_2$	;	$= -64800$
$2\ H_2O_2 = 2\ H_2O + O_2$	;	$= -56660$
$CO + Cl_2 = COCl_2$	;	$= -16260$

It would seem safe to predict, then, that only those reactions which involve a slight negative or a positive free energy change will follow a photochemical equivalence law. For the other reactions light seems to be capable of starting a chain process which continues until it comes to an accidental end. As Nernst[9] has pointed out an "acceptor" which neither multiplies nor diminishes the products of the primary reaction, but transforms them directly into the equivalent quantity of finally measured product should give rise to a reaction which obeys the photochemical equivalence law. This point has been studied by Pusch[10], who studied the action of bromine on

[9] Nernst, Zeit. Elektrochem., 24, 335 (1918).
[10] Pusch, ibid., 24, 336 (1918).

hydrogen, heptane, hexane, toluene and hexahydro-benzene under the influence of light. The first took place much less than was predicted by theory, several quanta being required to cause one molecule to react; the next three took place more than was predicted by theory and hexahydrobenzene reacted according to theory. Since the free energy changes in organic reactions are little known, it is impossible to correlate these results with the rule enounced above.

The action of light on the hydrogen-chlorine reaction has formed the subject of many studies. As a result, it is impossible to state at present what the function of the light really is. Stark[11] suggests that the action of light is to *loosen* the valence electrons. It is impossible to make any generalization of this sort, and it is probable that the action in the hydrogen-chlorine reaction is not connected with the valence electrons as such but with the molecule as a whole. In some recent experiments[12] it has been shown fairly conclusively that a mercury surface which has been acted on by wave lengths below the photoelectric threshhold reacts more readily with nitrogen dioxide and with oxygen than an unactivated mercury surface. Since fields which would tend to hinder the elimination of electrons from the surface caused the speed of the reaction to become normal, it seemed that the emission of the electrons was the deciding factor. A large number of molecules of HgO were formed for each electron emitted, and since the free energy change is negative, this reaction should be classified as a "secondary" light reaction.

In conclusion, it seems that the field of photochemistry is in a rather unsatisfactory state from a theoretical standpoint. Much work is being done on synthesis of organic compounds, especially those compounds formed in plants by the action of sunlight and of certain carbohydrates from formaldehyde, and these reactions may lead to very important conclusions from the standpoint of the biologist.

[11] Stark, Atomdynamik, Leipzig, 1911, Vol. II, p. 207.
[12] Moore and Noyes, to appear in the June number of the Journ. Amer. Chem. Soc.

A LABORATORY EXPERIMENT FOR TESTING THE EFFICIENCY OF A SCREW JACK

A. P. Carmen and R. F. Paton, University of Illinois

Our object in devising this experiment has been to get a feasible quantitative college experiment which would fix the principle of work and the concept of efficiency of a machine. We chose as the machine a small screw jack, the particular jack being an inexpensive one used to lift light weight automobiles. The apparatus is shown in Figs. 1 and 2. The hand lever was removed from the gear

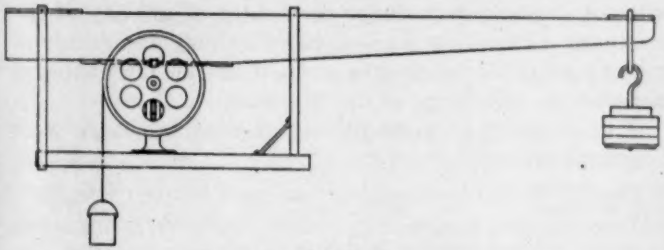


Fig. 1

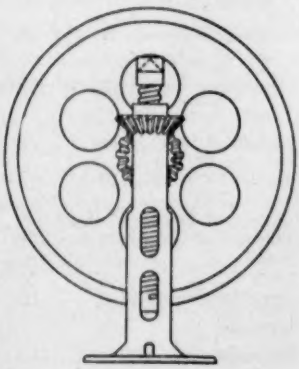


Fig. 2

wheel of the jack and a disk was substituted. The "power" force is applied as a weight hung by a wire cord which is wound in a groove on the periphery of the disk. This applies a moment of force to the small gear wheel

which acts in turn on the gear turning the screw on the jack. The "weight" force which is overcome consists of a number of large iron weights hung on the end of a lever. The fulcrum of this lever is at the opposite end of the bar and the "power" force on the lever is the force exerted by the jack. The lever as constructed by us consists of an oak beam 1.5 inches thick, about 4 inches wide and about 70 inches long. The upper end of the jack screw was fitted with a wedge-shaped piece and this rests on an iron plate screwed on the lower part of the oak beam. The point of application of this "power" force can thus be shifted along the lever bar. This point of application will not in general be under the center of gravity of the lever bar so that the work done in raising the center of gravity must be taken into account in the final calculations of the efficiency of the machine.

The following is a sample set of readings made with this apparatus.

weight of lever	6490	grams
pitch of screw	.847	cm
distance of fulcrum to jack	46.0	cm
distance of fulcrum to center of gravity of lever	66.0	cm
distance of fulcrum to weight	166.0	cm
distance "weight" is shifted for two revolutions of disk	6.35	cm
distance "power" force moves for two revolutions of disk.	177.8	cm
weights at end of lever	12410.0	cm
"power" weights in bucket required to just lift above "weight"	2040.0	gm

From the above data, the student calculates directly the following:

ideal mechanical advantage of jack	105.
actual mechanical advantage of jack	26.8
ideal mechanical advantage of lever	.266
actual mechanical advantage of lever	.230
ideal mechanical advantage of combined machine	28.0
actual mechanical advantage of combined machine	6.08
efficiency of jack	25%
efficiency of lever	86%
efficiency of combined machine	22%

Laboratory of Physics
University of Illinois
April, 1924

THE RELATION OF FLUE GAS ANALYSIS TO THE EFFICIENCY OF THE OIL BURNER

GEORGE T. PARKER AND H. A. GEAUQUE, LOMBARD COLLEGE, GALESBURG

INTRODUCTION

The extensive use of fuel oil in all types of furnaces gives economic importance to standards of furnace control. The small installation is seldom controlled from the measurements of a testing engineer as the variations in the efficiency of the installation seldom amount to enough to warrant the employment of an engineer. The large installations, however, are being controlled by the modern methods which have been developed for coal fired furnaces. These methods are tests of the intensity and quantity of combustion and, when applied to the combustion of fuel oil, indicate the efficiency of the furnace, provided, of course, they are interpreted in the right way.

Because of the rapid development of the oil burner industry, the discussion of the efficiency of the oil combustion has been left largely to the salesmen or promotors, while the factory engineers have been busy developing the production efficiency of the plants. Efficiency standards have been set by argumentation rather than being based upon information gained in the industrial laboratory. As a result many exaggerated claims have been made regarding the efficiency of the furnace, including claims of more than 17 per cent carbon dioxide in the flue gas. Of the many claims of advantage of the oil burned over the coal fired furnace the flue gas analysis should show the relation in efficiency of starting, change in load, and complete combustion.

COMBUSTION EFFICIENCY

The type of fuel used varies considerably, but with the lighter fuel oils, the average hydrocarbon indicated by the properties of the oil is probably represented by the formula $C_{10}H_{34}$. The quantity of this oil, or the percentage, cracked during vaporization, probably varies considerably, but the ease with which it is distilled would indi-

cate that it is stable at the moderate temperatures. The vaporization in the burner is at a point where a large quantity of air is being admitted to the fire pot. The cool air keeps the temperature of this part of the fire pot very much lower than that of the flame. On the assumption that only a very small per cent of the hydrocarbon is cracked, the maximum percentage of carbon dioxide in the cooled flue gas can be calculated by calculating the combining volumes from the equation,

$$2C_{16}H_{34} + 49O_2 = 32CO_2 + 34H_2O$$

If we assume that the ratio of oxygen to air is 1 to 5, the reaction will be expressed by volume as follows:

2 volumes Distillate + 245 volumes Air =

32 volumes CO_2 + 196 volumes N_2 and inert gases

This gives us a ratio of 32 volumes of CO_2 in a total of 228 volumes of flue gas, which gives a percentage of 14.03% carbon dioxide as the maximum percent possible in the cooled flue gases. The maximum carbon dioxide from oil combustion is calculated by F. D. Harger[1] as 15.395% from the analyses of the oil given as C = 84.0; H = 14.0; O = 1.2; S = 0.4; N = 1.7. The calculation of the maximum percent of carbon dioxide possible from the combustion of the above oil is 12.52%.

The cracking and dissociation at the high temperature of the flame give the combustion a process of oxidation of carbon and hydrogen as dissociated in the flame rather than a molecular reaction. This change in the condition of these elements would not, however, change the resultant compounds found in the flue gases.

EXPERIMENTAL

Two types of burners were studied—the vaporization and the spray types. The temperatures were measured by means of a thermo-couple and potentiometer. A modified form of the Orsat gas analysis apparatus was used in analyzing the flue gases.

In the spray type found in the market at present, the oil being sprayed by air pressure, the quantity of air seems to be governed by the necessity of spraying the oil rather than by the amount necessary for combustion

[1] F. D. Harger, Fuel Oil, Vol. 11, No. 6, p. 9.

and by attempts to lower the air supply. The study of the effect of the air supply upon the efficiency resulted in the stopping of the spray and the burner, of course, was extinguished. The maximum carbon dioxide from this type of burner was found to vary between 4 and 5 per cent, 4.6 being the average. These conditions can probably be made more favorable by several adjustments, but it was found impossible by the author to keep the oil supply constant and change the amount of air supplied to the burner. In this type of burner, the oil supply, of course, depends upon the velocity of the air current.

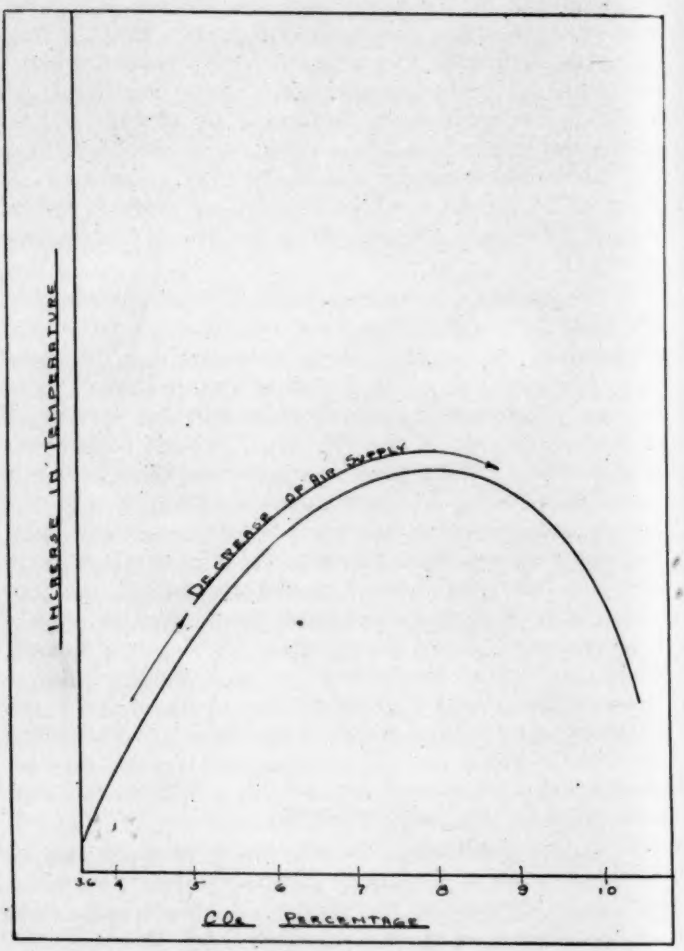
In the studying of the vaporization type of burner, the air could be controlled and the relationship of the temperature to the quantity of air necessary for the maximum efficiency was easily found. Figure 1 shows the relationship between the temperature and the percentage of carbon dioxide in the flue gas. The oil supply was held constant during these readings and the air supply was diminished. The maximum air supply that the burner could possibly use was used as a starting point and the readings were taken as the air supply was diminished. As is indicated on the curve, both the percentages of carbon dioxide and the temperature were found to increase to approximately 8.3% carbon dioxide. After that a quick break in the curve, indicating a lower temperature, shows that above this point, at least, the efficiency was quickly lowered on the carbon dioxide curve between 6.6 and 8.3%. There was only a comparatively small change in temperature, and this would indicate that an average in this range would be perhaps the most efficient in this condition. The conclusion from a study of the flue gases of the ordinary marketed types of oil burners can be summed up as follows:

1. A control of the air supply is very advantageous.

2. The air supply should be such that the carbon dioxide in the gas should come between 6.6 and 8.3%.

3. The construction of the burner should be such that a change in regulation would not affect the mechanical action of the burner.

4. An excess of forced air should be avoided because of the serious cooling effect it has upon the flue gas.



CHEMISTRY OF SEWAGE TREATMENT

A. M. Buswell, Chief, Illinois State Water Survey and Professor of Sanitary Chemistry, University of Illinois

A recent conversation between an eminent scientist and a successful business man, which the speaker chanced to overhear, will serve to introduce the subject of this paper and to emphasize the need for greater general enlightenment in educated circles. Asked the scientist, "Is it possible to purify sewage?" "Oh yes," the business man replied, "We are building a sewage treatment plant for our town. I think it is to be some sort of an incinerator!"

Almost every chemical graduate has a general notion of how leather, rubber or Portland cement is manufactured, and even high school students of chemistry are likely to know how gas is produced and how water may be softened. These and other chemical processes are discussed both in the elementary and advanced texts on industrial chemistry. But the treatment of human and industrial wastes, while essentially a chemical process, is almost wholly neglected. Naturally, therefore, the scientifically trained student knows nothing about sewage treatment unless he has taken a special elective course.

In introducing the subject of sewage treatment I want therefore to say a few words about the amount and composition of sewage. Sewage may be defined as the combined water carried wastes of a city or community. In addition to the human and household wastes it may contain the by-products from almost any variety of industry; it may contain the washing from streets, and unless separate drains are provided it will include the surface run-off during rain.

In amount, the sewage includes the ordinary water consumption plus what is contributed from rain and other sources. The dry weather flow usually approximates rather closely the water consumption. This amount varies greatly between different localities. In Europe the sewage flow in dry weather will run from 20 to 40 gallons per capita per day. In this country it will be from

80 to 100 gallons for smaller residential communities and on up to 200 gallons per capita per day in some larger cities. This flow is not uniform throughout the day but rises and falls with the tide of human activities.

The amount of organic matter which is present in sewage is relatively small. Some notion of the concentration can be gained by imagining the total daily bodily wastes of one person plus his share of the industrial wastes diluted with from 100 to 200 gallons of water. Yet small as this amount of organic matter is, it must in general be reduced by 70% to 95% before the sewage may be discharged without offense.

The number of urban districts in the United States which have sewage treatment plants, or rather the number of those which do not have such plants will, I think, surprise you. Mr. Langdon Pearse, of the Sanitary District of Chicago, has compiled some interesting data in this connection which appeared as a committee report to the Society for Municipal Improvements. He states that of 68 cities in the United States of 100,000 population or over, including a total population of 27½ million, only 17 cities or a total population of 8¾ million have sewage treatment works. In other words, less than one-third of our larger cities treat their sewage. In the next group, in cities of 25,000 to 100,000, with a total population of 10 1/3 million, only about 12 per cent have treatment work.

As in the case in most young industries, the importance of technically trained operating personnel is not generally realized. The larger cities with treatment works employ a regular staff of chemists or at least a chemical consultant employed intermittently. Of the 26 cities of from 25,000 to 100,000 population with sewage plants, only six employ trained operators, while in cities under 25,000 anybody from the Mayor to the dog catcher may be detailed to look after the sewage works. This condition cannot long continue. Sewage treatment is a complex process and cannot be carried out successfully except under the supervision of trained chemists.

In discussing the manufacture of relatively pure water from the combined water carried wastes of a modern city

I want to invite your attention, first, to the raw material and the final product which must be produced; second, to typical factory layouts in which the process may be carried out; and third, to some of the chemical reactions which take place.

1. *Raw materials.* A general idea of the raw materials may be gained from the statement that the amount of sewage is very close to the cities' total water consumption. This ranges from 75 to 150 gallons in American cities per capita per day. In Chicago, due to the enormous waste of water, the consumption is over 300 gallons per capita per day. When the wastes from one person, even including his share of factory and trade wastes, are diluted with such a large volume of water it is apparent that the amount of organic matter per gallon of sewage is comparatively small. And yet it is exceedingly objectionable.

Sewage is most concentrated and the flow is greatest during the day. It drops off both in concentration and flow, reaching a minimum about midnight to 1:00 or 2:00 o'clock A. M. In addition to the hourly variation in concentration and flow, sewage also varies with the days of the week and the seasons of the year. In fact, so great is the variation in sewage that it is impossible to make a sufficiently reliable laboratory analysis of it. Where any considerable sewage treatment work is contemplated it is necessary to erect an experimental plant to try out various methods on a sufficient scale to allow for the effect of the numerous variables.

(2) *Typical factory layouts.* Although each plant must be designed to handle the particular local problem, there are certain steps that are usually made use of in purifying sewage. Time will permit us to mention only the two most important methods.

The new plants being built at Decatur and Urbana-Champaign may be taken as typical Imhoff tank and sprinkling filter installations. The sewage flows first through bar screens which remove larger debris of more than 2 to 3 inches in size. Next it passes through grit chambers in which large gravel, cinders, and grit particles settle out. Next it may be passed through some sort

of fine screen. Screens do not happen to be used in the two new installations referred to. The sewage, still flowing at a fairly high velocity and carrying considerable matter in suspension, flows now into tanks where the velocity is reduced and sedimentation takes place. The tanks are of the so-called Emscher or Imhoff design, invented by Dr. Karl Imhoff and first used in the Emscher district of Germany.

The tank is a sort of two story affair in which the sedimentation takes place in the upper chamber. The sludge slips through the slot into the lower compartment where it is subjected to septic digestion. One of the features of this tank is the separation of a biolytic or digestion chamber. The vents at the sides allow the escape of gaseous products of digestion without stirring up the sedimentation chamber. This separate digestion of the sludge prevents the fouling of the liquor in the sedimentation chamber so that the effluent has a mild musty odor rather than the septic odor of the older septic tanks.

The effluent, now very materially improved and having no large floating particles but still with a distinct milkiness, may in some cases be discharged into the stream if the stream has sufficient volume. In most cases, however, it is passed through sprinkler nozzles on to a so-called filter in which the action is not one of filtering or straining at all, since the medium is broken rock of 2 to 3 inches in size. A slimy film soon develops on the surface of the stone, which acts in some way or other to take up all of the milky colloidal organic matter and oxidize much of the nitrogen to nitrate. The effluent of a trickling filter is perfectly clear, and it not only does not contain any putrescible organic matter but the nitrate constitutes what might be called an excess stability. The effluent is really of better quality than the water in many of our muddy prairie streams.

From time to time these filters "unload" a sort of black humus which usually is caught in secondary tanks of the Imhoff type. This process has for its net effect the digestion, liquifaction and oxidation of the organic matter, the end products being $(NH_4)_2CO_3$, NH_4NO_3 and a black humus containing 95% or more of water, and

known as the sludge. This sludge is siphoned off from the digestion chamber of the tanks from time to time, drained on gravel or sand beds and hauled away. It is comparatively poor in nitrogen, most of that element having been converted into soluble salts. In some cases it is sold for as high as $2.00 per load.

The activated sludge process which is rapidly coming into favor substitutes an aeration tank and settling tank for Imhoff tanks and filters and is very much more compact.

The sewage, together with about 25% by volume of returned sludge, enters one end of the tank and the two are thoroughly mixed and aerated by means of air blown in through porous plates at the center and bottom of the tank. In from three to six hours the sewage is completely clarified, considerable nitrates are produced and the mixture passes on to settling tanks. The settled liquor is clear and stable and is discharged into the stream. The sludge, which contains 97-99% moisture, is partly returned to maintain the process while the remainder is dried and sold for fertilizer.

The sludge differs radically from Imhoff sludge. Activated sludge has practically the same chemical composition as microbial protein, containing from 7 to 10% of nitrogen. It is a very valuable fertilizer, but unfortunately no cheap method of drying it has been worked out. Much progress is being made by the Sanitary District of Chicago and elsewhere at the present time and the problem appears far from insoluble.

I have purposely avoided discussing the question of sludge drying from lack of time.

CHEMISTRY OF SEWAGE PURIFICATION

Two rather opposing theories have been proposed for the explanation of the reactions in sewage treatment, more especially the clarification and nitrification which takes place in the activated sludge tank or on the trickling filter.

The one is the Hampton Doctrine of Travis which Ardern summarizes as follows: "According to this theory the purification process is primarily and essen-

tially a de-solution effect brought about purely by physical causes, and any bacterial or biological action is definitely ancillary." Dr. Remsen is quoted as saying that the value of a theory is to be judged by the experimental work which it stimulates. Judged on this basis the Hampton doctrine does not make much of a showing.

The other theory is that of Dunbar, with perhaps some modifications, and holds that the results are brought about largely by biological catalysts which produce biochemical reactions.

If one examines particles of activated sludge under the microscope he is impressed immediately with the fact that there is practically no adsorbed, precipitated or coagulated amorphous matter in these sludge particles, but that they are composed entirely of active growing microscopic organisms of varieties ranging from true bacteria up through the giant bacteria, with occasionally molds and yeasts, and including as well, a variety of free swimming and attached protozoa. These communities of microorganisms must obtain food, and this food must be supplied from the colloidal and dissolved matter and salts in the sewage. From what we know of the metabolism of microorganisms it is probable that the unicellular forms are absorbing through their membrane such soluble forms of organic matter as are able to pass through this membrane, and that they are also secreting enzymes which are capable of peptizing or liquefying colloidal particles too large to be directly absorbed. Protozoa, on the other hand, can easily be seen to approach and ingest visible particles of organic matter. This biological theory of the action of activated sludge might be summarized and emphasized by proposing what seems to be a rather striking analogy, namely, that the purification of sewage effected by microscopic communities appearing as flocs is entirely similar to that of disposal of garbage by feeding it to hogs. It does not seem probable that adsorption of colloids or mechanical precipitation plays any greater part in the metabolism of microorganisms than they do in the digestion of the larger animals. One serious objection to the colloidal theory of coagulation is that the

colloidal particles in sewage and the activated sludge particles are, so far as we are able to determine, both negatively charged. Since adsorption of colloids is most effective between oppositely charged particles it should not be applied to the conditions of the activated sludge particles without reservation. Furthermore, adsorption is an almost instantaneous action, while considerable time is required for the activated sludge reaction.

The biological theory suggests a somewhat different notion of the importance of oxidation in sewage purification than that ordinarily expressed. When garbage is disposed of by feeding to hogs, only as much oxidation takes place as is required to furnish energy for the life processes of the hogs. Final oxidation does not take place until the pork chops are eaten and burned up in the body to furnish human energy. If the analogy of this process to sewage disposal is admitted, oxidation appears as an incidental reaction. Biochemical precipitation of colloids would appear to be the important phase of the reaction.

The Sludge-Digestion Spiral—In nature organic matter is worked over by succeeding generations and races of micro-organisms until a large percentage of it has been broken down to ammonia, nitrates and carbon dioxide, leaving a relatively small amount of black humus as a residue. The course of this reaction might be represented by a spiral. Suppose at a point A we start out with the dissolved and colloidal organic matter in sewage. Microbial spores then develop, producing bacteria, molds and sometimes even higher forms whose nourishment is drawn from the organic matter, until when we arrive at point B all of the organic matter has been taken up to form the living substances of the growths which develop. If these growths continue their life processes they produce a certain amount of carbon dioxide and ammonia, and then eventually die and decompose, bringing us to the point A′, where we again have dead and more or less liquefied organic matter. The distance from A to A′ would represent what some authorities refer to as the "wet-burning" or "moist combustion" which has taken place during the first lap around the

spiral. If we continue to go round and round this spiral we eventually arrive in nature at a condition where a fairly considerable portion of the organic matter has been mineralized and a black stable humus substance remains.

Sewage treatment by means of biolytic tanks, sprinkling, or contact filters and subsequent secondary tanks gives us practically the result indicated by the spiral. The heavy solids are attacked and worked over by certain groups of bacteria in the sludge digestion chamber of the biolytic tank until practically nothing but a black humus remains. The liquefied product, together with the collodial and dissolved organic matter in the sewage, is taken in by the organisms of the biological jelly on the sewage filter. In this jelly the same spiral of activities goes on. A cross-section cut with a knife through the growth on the sewage filter stone shows on the outside the new whitish growth composed of various types of bacteria and protozoa. Just below this new growth there is a layer of less active dying or dead bacterial filaments upon which varieties of protozoa are feeding. These protozoa in turn die, and various forms follow, undoubtedly, including some of the same anaerobic forms which are active in the sludge digestion chamber of the tanks, which produce immediately adjacent to the stone a black stable humus. From time to time this humus sloughs off and is finally worked over in the digestion chamber of the secondary tanks. As a result of allowing this process to go on to the limit we obtain a relatively small amount of comparatively inoffensive sludge of low N_1 content, the N_2 having been largely converted into ammonium salts. The process, however, requires rather a large area for its practical application.

In the Activated Sludge Process, we start out with the idea that the sludge is a valuable fertilizing material, and therefore for the most economical operation of the process we should try to get as much sludge as possible. Since it is a biological process the course of the reaction will be along the course of the same spiral described above. But since we are going to considerable expense in order to provide a condition favorable for the growth

of the microscopic life, namely, by blowing air into the sewage, we will waste considerable effort if we allow the process to proceed very many laps around the spiral. The most efficient process would seem to be one which removes the sludge as near the point B as possible; that is, as soon as a luxuriant growth has been developed and before any of this growth begins to die and decompose. This fact is the fundamental distinction between tank-and-filter treatment and activated-sludge treatment, the object of the former being to go round the spiral approaching the center as nearly as possible, that is with the maximum of wet-burning, while the latter should go only to the point B.

There is also a mechanical difference between the activated-sludge process and the tank-and-filter system. Hering has shown that the amount of purification is proportional to the surface exposed. Since it is necessary to use rather large stone in filters to avoid ponding or clogging, it is obvious that the ratio of surface to volume, that is the efficiency per cubic foot, is comparatively low, while in the activated-sludge process the floc surface is relatively enormous, being in the neighborhood of 500 sq. ft. of surface area per cubic foot of aeration tank volume.

It will not be possible to discuss all of the chemical changes which take place, but I want to consider briefly the nitrogenous compounds and the changes which they undergo. In this field we find that the chemistry of soils and fertilizers and the chemistry of sewage have gone hand in hand. Chemists in one line apply freely the advances made in the other. Although the chemistry of nitrogen and the changes which it undergoes in nature is one of the oldest subjects of chemical investigation we find that there is much misinformation in the literature and much still to be learned.

When bacterial enzymes attack the organic matter of sewage, progressive hydrolysis takes place with the formation of ammonia. This is known as ammonification and is brought about by a variety of organisms.

If aerobic conditions prevail, the nitrifying organisms oxidize nitrogen to nitrites and nitrates and the mineralization of nitrogen is complete.

These reactions are pretty well understood and in fact a matter of common knowledge among chemists. The fact that these reactions can take place in the reverse direction has, however, but recently been demonstrated.

If we start with nitrates we find that under anaerobic conditions they are reduced. This process is generally referred to as denitrification and most authorities state that denitrification results in loss of nitrogen. Experiments in our laboratory and elsewhere indicate that this is not true. Nitrates when reduced are synthesized into protein, the living protein of micro-organisms and bacteria. Likewise free ammonia in some cases decreases during the process of sewage treatment, but here again nitrogen is not lost but protein is formed. Thus we see that in sewage treatment we may have protein compounds undergoing hydrolysis, liquefaction and oxidation, or the reverse action may take place and protein may be precipitated.

The carbon and sulfur cycles are equally interesting but would be beyond the limits of the time alloted this paper.

THE INTER-RELATION OF THE SCIENCES

PAUL L. SALZBERG, KNOX COLLEGE

The study of the sciences as unified and related subjects has an interesting analogy in the field of physical chemistry. Research in radio-activity and in atomic disintegration has led to a conception of the elements which points out a fundamental unity between them. Recent theories on atomic structure seem to indicate that atoms of helium are the most important components of the positive neucleus of every atom, and that differences in elements are not due to differences in matter but merely to differences in numbers and arrangements of these atoms of helium and the electrons which revolve about them. Now it is important to note that although the conception of elements was originally based on the assumption that there were different kinds of matter, this classification of simple substances is still justified not only by their obvious differences but also by their practical value to the chemist.

In the same way the sciences may be shown to be as closely related without detracting from the importance of the classification into departments. This classification is necessary because the general situations presented by nature are too complex to be studied as units. Nature presents an apparently simple phenomenon such as a rainfall, but history tells us that those who attempt to solve its mysteries without classifying its various aspects completely fail to arrive at valid conclusions. Mythical gods such as Thor, the God of Thunder, were invented to explain a situation too complex for their method of research.

Instead of drawing conclusions directly from nature's phenomena, the modern scientist idealizes certain aspects and studies them separately in the various departments. It was in accordance with this scheme that Mr. John Aitken discovered the importance of dust in precipitating a rainfall by passing steam into two large receivers, one filled with ordinary air and other with filtered air. The first was filled instantly with condensed vapor in the usual cloudy form while the other remained quite

transparent. In the same way Schönben explained the fresh penetrating odor noticeable after an electric storm, by passing an electric spark through oxygen and identifying the same odor.

Although our classification is entirely justifiable we must remember that nature has no such scheme in mind when she provides her phenomena, and consequently most of them do not fit conveniently into our water tight compartments. We have a good example of this in osmosis. Its character and explanation is physical, but its importance comes in chemistry, as a proof of ionization, and in biology where it explains the rise of liquids in the roots of plants and trees.

It is because our classification is more artificial than natural that we are constantly finding relations between the sciences. Each science depends upon the others, and examples of this interdependence are numerous.

The fundamental conceptions of chemistry are physical in character as well as in the method of arriving at them. The atomic theory is undeniably physical, but, at the same time it is true that its proof is based on contributions from both sciences. Historically, the chemical law of combining weights was a strong factor influencing its adoption, but recently the objective reality of the atom has been established by calculation of its mass and dimensions from data obtained from radium emanation. The close approximation between results obtained in this way and those from more indirect methods is the physicist's proof of the atomic theory.

Other chemical conceptions are greatly enriched by considering them in the light of sub-atomic physics. Oxidation in chemistry originally was a narrow and restricted term which included only the addition of oxygen to metals. If oxidation is kept entirely within the field of chemistry, there is little possibility of broadening its meaning. It is true that it may be defined as the increase of positive valence, but where these valences come from is a problem of the physical chemist. We now define oxidation as the loss of electrons with the result that not only has the scope of the term been enlarged but the very nature of its mechanism has been

determined. Now oxidation is based on the ability to lose electrons so that whether it will take place in a given case can be predetermined by referring to the electromotive series which lists metals in the order of their ability to lose electrons.

Helium is an element which forms no compounds. The chemist would say that this is because it is inactive, but the physical chemist has gone much farther when he explains it as due to the inability of helium to lose electrons and thus gain a positive valence, while the phenomenon is entirely accounted for by the sub-atomic physicist who says that the helium atom is composed of a positive nucleus and negative electrons which swing in an orbit which is in perfect equilibrium, so that there is no tendency for an electron to leave it.

Probably the most obvious contribution of physics to chemistry is in apparatus embodying physical principles. Whenever chemical changes or properties are not directly observable by the senses, the physical instrument is a necessary medium. When the hands cannot detect heat we use a thermometer; when the eyes cannot perceive the arrangement of the atoms within a crystal, we use X-ray diffractions to interpret this arrangement.

The spectroscope is a true product of the inter-relation of physics and chemistry, first because it was the outcome of joint research by a physicist, Kirchoff, and a chemist, Bunsen, working together in the same laboratory, and second because it has found application in both fields. To illustrate, Bunsen applied it to the analysis of water of certain springs and thereby discovered two new elements, caesium and rubidium. In the hands of Kirchoff it explained the dark lines in the sun's spectrum as being due to absorption, and as a result it became the means of determining the composition of other planets.

Another physical instrument of value to the chemist is the polarimeter. This apparatus is used for measuring the degree which an optically active substance will rotate the plane of polarized light. Its importance to chemistry came when it was found that some substances with

the same formula, which had hitherto been considered identical, differed in their effect on polarized light.

For example, lactic acid from beef extract rotated the plane to the right, being dextro-rotatory; lactic acid from the fermentation of milk sugar, with a certain ferment, was levo-rotatory, while the synthesized product was inactive. The chemist usually explains such isomers by a difference in arrangement of the atoms, but in the case of lactic acid only one structure could be conceived, unless, as Van't Hoff suggested, spatial relations were considered. So the immediate importance of the polarimeter was the incentive to study organic structure.

The inactive lactic acid referred to was found to be a mixture of the dextro and levo forms, so that the problem arose of separating them. In most cases the chemical and physical properties of two optically active isomers are the same except in their effect on polarized light, and so the usual method of separation based on differences of properties was difficult to apply. But here biology made an important contribution in the form of certain bacteria, which, when introduced into the mixture, would destroy one and leave the other. These living cells secrete complex proteins called enzymes which catalyze organic decomposition in order to use the energy liberated. Now in accordance with laws of evolution each organism will be provided with the enzyme which can attack the substances it finds in its environment, and consequently one which will be indifferent to most other substances. The mould penicillum glaucum is thus capable of destroying levo-lactic acid but is indifferent to the dextro-form, so that when it is introduced into the mixture, it will leave only the latter acid.

Aside from this practical value the study of enzyme catalysis is of the greatest importance in biological chemistry. The value of a compound as a food is largely dependent upon its ability to undergo decomposition, and since these decompositions are brought about in many cases only through the agency of certain enzymes, the question of food value becomes largely one of whether the necessary enzyme is present. The enzyme's selection of compounds has been shown to be according to the

stereochemical structure of the molecule, and so one of nature's most fundamental processes, that of digestion and metabolism, may be quite as much chemical as biological.

Other complex problems of biology can often be simplified by resolving them into their physical and chemical components. Professor Lillie has shown that nerve currents, the biological basis of psychology, are essentially electrical and chemical in nature. Also, Sir Wm. Bateson, an eminent authority on evolution, believes that all its theories must be in accordance with facts of physics and chemistry. It is from this point of view that mutation, the act of differing from parent to offspring, has been resolved into problems of these two departments. Crystallization, diffusion, electric or magnetic lines of force, and harmonic vibration are factors which make for similarity between organisms from the same source; so that to find conditions which would modify these factors is to form a basis for the explanation of mutation. The contribution of physics has been such conditions as temperature and pressure, while the chemist has been studying the effect of colloids on crystallization, all of which show that mutation is not as obscure a process as it appears on the surface.

The biological discovery of insulin as a cure for diabetes had little practical value until the chemist had worked out a method of preparing it in quantity. The biological method was to extract it from the pancreas of a dog, by first destroying the pancreatic juices in order that they would not digest the insulin. Since this process required six months it was impractical, and the problem was turned over to chemists. After a year of research they were able to prepare it from the sweetbreads of cattle so that now the industry is able to supply the 18,000 people in the U. S. who take insulin daily. The function of insulin is to destroy the excess sugar in the blood, and the amount administered must be exactly in proportion to this excess, for an overdose of insulin is harmful to the patient. The difficulty is that in a given dose the amount of pure insulin is not known, so that its strength has to be determined by injecting it into a

rabbit and measuring the amount of sugar destroyed. The present problem of the chemist is to prepare a compound of such purity that its strength will be known directly, thus eliminating the trial and error method.

We have thus shown how each science is dependent upon the others. It may have become evident that whenever one science has contributed to another, the contribution comes back much more useful to its original department. The chemist borrowed the electron theory from the physicist, developed it as an explanation of oxidation, then returned it to the physicist much more valuable because now he could use it in explaining the Voltaic cell and the storage battery. In the same way the spectrum came back to the physicist in the form of the spectroscope which he could use in explaining the dark line spectrum of the sun and in determining the composition of other stars. The biologist's knowledge of enzymes was greatly increased by loaning them out to the chemist for use in stereochemistry. Biological methods could never have found that the ferment's choice of foods depends upon so insignificant a thing as the interchange of a few hydrogen and hydroxyl groups.

It is such illustrations as these which show that if the inter-relation of the sciences is put to practical use, as is being done in the border-line sciences, it will lead to a greater exhaustiveness and accuracy in scientific research.

PAPERS ON GEOGRAPHY AND GEOLOGY

THE AIM IN TEACHING FOREIGN GEOGRAPHY

HERMAN T. LUKENS, FRANCIS W. PARKER SCHOOL, CHICAGO

Traveling is likely in the future to become increasingly frequent, as governments will cease to hinder and will begin to recognize that it is to the public interest for more people to meet and mingle with those of other nations. Seeing this, the authorities will begin to aid travelers to remove natural obstacles, instead of putting artificial ones in our way.

The greatest need for all travelers is knowledge of every kind. He who knows the most before he starts will learn the most on the way. Over the door of the Union Station in Washington is this inscription: "He who would obtain the wealth of the Indies must carry it with him to the Indies."

2. The study of foreign peoples should develop the appreciation of the real brotherhood of mankind, our mutual interests, and our true interdependence.

3. The course should make plain and rather dwell upon points in which other peoples excel our own. There should be much comparison of natural resources, climate, and manufactures. Our geographies make the United States too much the center of the world and minimize the relative importance of other countries. It does us good, therefore, to get hold of a British atlas, or to refer to a Japanese chart, or a German guide book, or a French or Dutch colonial publication with a different world view. It is something to stir us out of narrowness to realize that every new day starts in Japan, while Europe and, later still, America are finishing up the preceding day.

4. Differences of religion, custom, and faith should be presented without bias or prejudice, as likewise differences in climate, dress, resources, and manufactures. Somehow or other, most of our pupils get the idea that foreigners are ignorant and stupid, inferior to ourselves in ability and inheritance. Perhaps ninety percent of what we teach about other races involves the assumption that they are inferior to our own, and is more cal-

culated to instill prejudice than to lay the foundation for mutual understanding.

5. All of our ideas of the shapes of countries come from maps and models, and likewise nearly all our ideas of their size. While, however, we learn the shapes correctly, we fail woefully in getting a correct idea of the relative or the actual size of foreign countries or of distances between places. This is due directly to having such a variety of scales to our maps that our resultant memory image has shape only, but no scale by which we can calculate or think size adequately.

To most of us, our Western States are thought of as too small and New England as too large; we think Great Britain as relatively too large and Russia as too small. Europe is too large and Asia is too small in our mental map to enable us to make true comparisons. For illustration, Missouri and Washington are each larger than all of New England, but do they seem to have that size in our thought? The Yellowstone National Park is about the size of Porto Rico and is larger than Rhode Island and Delaware combined. Java has the same area as England, and Ceylon is half as large. Maine is larger than Ireland. New Zealand is considerably larger than the Island of Great Britain, with England, Scotland, and Wales. Formosa is larger than either Maryland or Holland. Borneo is larger than Texas. India stretches as far as from the mouth of the Chesapeake to Panama. Korea is larger than either Idaho, Minnesota, or Utah. From Peking to Canton, China, it is about as far as from Duluth to New Orleans.

How many of us think of these countries in their true size? It is a great deal as tho we used a pair of field glasses in looking at part of the earth's surface and then reversed the glasses and looked thru the other end at other countries. It is thru this sense impression from maps of varying scales that our minds are furnished with memory images that are inconsistent with reality. The scale of the maps in our atlases and on our wall charts is determined chiefly by the convenience of the printer and the cost in making the pages of uniform size and therefore of varying scale. The

price we pay is utter confusion in our source impression of size.

Scales should be standardized into one uniform set of scales, easily transferable from one into another; e.g. 100 miles to an inch, 50 miles to an inch, 20 miles to an inch, 10 miles to an inch, and 1 mile to an inch. It should be possible to get a map of any country in any of the standard scales. This would make possible direct comparison of size by superposition of the maps. Such scales as 6½ miles to an inch and 22½ miles to an inch, simply should not be used, because the distances on such a map will not be translated into miles. Recent publications are moving in this direction, but confusing scales are still very abundant.

STREAM POLLUTION, A GROWING MENACE TO WATER SUPPLIES

FRED R. JELLIFF, PRESIDENT KNOX COUNTY ACADEMY OF SCIENCE

The pollution of the streams of Illinois by sewage and factory waste has reached a point where a statewide protest should be formulated and a campaign organized to reduce the present evil and to prevent further increase. The public must be informed and positive action must be taken. We seem to have ample law and no fault is found on this score; we have a State Board with power to act, and we have no desire to criticize the Board. Stream pollution is largely the result of indolence and ignorance, which do not take into account the effects, and which seek the easiest way of getting rid of waste and sewage. A late report of the Illinois Department of Health says: "Contaminated water is a mighty dangerous enemy." It is time that attention be given in every institution and every commercial body of the State to the menace that this indiscriminate practice constitutes.

First I will emphasize the fact that the time is approaching when as much as possible of the water that falls from the clouds must be conserved for animal and vegetable and industrial consumption.

In my own county last year a great railroad company was forced to haul water from an artificial reservoir forty miles away; an electric light and power company was reduced to an extremity to procure an adequate supply of the right kind of water; farmers were compelled to haul water for stock, streams were so dry that one could walk on their beds, and municipalities were at their wits' ends to obtain water fit to use and in ample quantity. The procuring of unspoiled supplies is each year becoming more difficult.

The source of our supplies is the rain. Is it possible to formulate a policy by which a larger quantity of this may be made available before it is contaminated with organic, animal or mineral impurities? Authorities give the average annual rainfall for the State at thirty-five inches. In years of maximum rainfall, a total of fifty

inches or more may be precipitated, while in years of least rainfall the total may not be more than twenty-four inches or even less. It is in these years of least rainfall that the need of conservation of water becomes most apparent, and when the effects of pollution become most acute and dangerous.

Drift formations of various depths cover most of our State and the yellow clays, sands and gravels absorb water which is diffused through their layers. Below the yellow clay lies a blue or bowlder clay that as a rule is impervious to water. Part of the rain sinks through the soil and subsoil into this yellow clay, which thus over a large area is a water bearing stratum. Water is retained in it because of blue clay underneath. This underground reservoir is not by any means inexhaustible, although our State report properly calls it our largest and most valuable supply, and surface wells over much of the State extend into it. The level in this formation has been lowered, and it can no longer be relied upon, as in pioneer days, to meet the increasing demands. Professor J. A. Udden in one of the early Bulletins says: "The general level of the ground water is being lowered." As early as 1908, the Bulletin spoke of the insufficiency of the yellow clay supply.

Another important consideration is that the widespread tile drainage of the surface has accelerated the run off so that not so large a quantity of water as formerly reaches the yellow clay. In a general way one can figure this run off at nearly one-third of the precipitation. It is estimated that nearly one-third is evaporated and at some seasons the proportion is greater. This leaves about a third to sink into the water bearing clays, sands and gravels, and a portion of this seeps out along the edges of the blue clay into the streams or breaks out in springs. Or very great economic importance, therefore, is what becomes of the portion that seeps into the clays or runs into the streams. It is on this that man and all other animal and even vegetable life must depend for most convenient supplies.

In the State Bulletin of 1913 it is stated that "With very few exceptions there are no sources of water supply

in Illinois that are free from possible contamination." Again it is declared that "all running streams are in danger of pollution." To this it can be added that many of our streams are now polluted.

The report of 1917 listed 433 municipalities with water supplies, of which 189 are from rock wells; 149 from drift wells; 67 from streams; 22 from Lake Michigan, and 10 from springs. To these must be added the tens of thousands of drift wells on private premises. One must also consider the hundreds of municipalities that do not yet have public supplies and whose needs must be kept in view.

Let us take first the pollution of the run off as exhibited in our streams. This is accomplished by the contamination of watersheds as well as by the discharge of waste and sewage into the channels. Cedar Fork, a small stream that flows through Galesburg, furnishes an illustration. Untreated sewage and much waste go into this and render the water foul and exceedingly offensive. These putrid discharges poison the water for eight to ten miles below the city. Estimating the watershed of the creek at seven square miles, when it crosses the west city limits, this creek would have in a year of average rainfall a run off of 1,500,000,000 gallons of water, with seepage of possibly a quarter of a billion more. Sewage renders all this absolutely unfit for use. If this water were conserved and impounded the gas company and other industries along its banks would have an ample supply. As it is, not a frog will venture into it for miles below the city and fish life was long since extinguished. Live stock will not drink the water and the stream, which might be an asset, is changed into a liability to the farmers.

This is not an isolated case by any means. Because it is easiest and cheapest, cities and factories all over the the State are using streams as open sewers and receptacles for waste. Neither lake, river or creek is spared. When we are discussing this, we naturally think of Chicago, but after an investigation I am convinced that most of the cities of the State, little and big, are equally guilty

and that poisoning of the water that falls pure from the clouds is nearly a general practice.

Let us take the pollution of the Illinois river, a stream once renowned for its beauty and charms. Through the drainage canal it receives much of the sewage of Chicago, and is so befouled by this that even the bottom of Lake Peoria, far down the river, has its blanket of filth. The main tributaries of the Illinois are the Kankakee, Des-Plaines, Fox, Vermillion, Mackinaw, Sangamon, and Spoon rivers and Crooked creek. The report of 1921-2 says: "The conditions of the sewage of the Illinois river are more pronounced than ever before."

The Fox river valley is quite thickly populated. The large cities of Elgin, Aurora and Ottawa use this as a sewage channel, not to mention smaller towns that find it a convenient depository. The discharges of twelve Elgin sewers pass into the river. Elgin is, however, building a sanitary sewer system. Aurora has nine sewers connected with the channel and there are sewer outlets from various private and manufacturing plants along the river, without treatment. Aurora is said now to be agitating a drainage district. An effort was made by the Rivers and Lakes Commission several years ago to abate the nuisance but the war interfered.

The DesPlaines river is polluted by the sewage of Joliet and by its factory waste. The corrupt condition of the Sangamon river is in the reports deemed a special object of concern. The sewage of Springfield and Decatur goes into it. The report of 1918-19 declares that Sangamon river is greatly polluted below Decatur. Decatur now has a million dollar sanitary sewer system, just completed, and that will take care of raw sewage and waste save in times of flood. Jacksonville and Bloomington empty their sewage into creeks but it finds its way into the Illinois river. The Kankakee river receives the sewage of Kankakee and there are other towns along it that may contribute toward fouling it.

Both Streator and Pontiac on the Vermillion river use it for sewage and waste purposes. In the State report of 1920-21 special mention is made of the foul condition of the river at Pontiac. Another comment is that "Dur-

ing a large part of the time, the Vermillion river below Streator consists only of sewage, industrial waste and mine water." We understand that Pontiac has built a disposal plant and that Streator is considering one.

Peoria is on the Illinois river, and its sewage and waste go into it. We have the authority of a fish and game official, familiar with the condition of the river there, that when the water is low the stream is in a foul condition and that the fish are liable to be affected injuriously.

It seems unnecessary to multiply instances, for this is enough to indicate the extent to which the Illinois river system is being used for sewage purposes. Practically all the large streams that flow into it receive more or less sewage. Although a state wide, detailed survey has not been made there is reason to believe smaller municipalities also are polluting the tributaries, so that from all parts of the river basin filth and industrial waste are being conveyed to the main streams and thence to the river itself. In its 1921 report the Commission says: "During the last year complaints have been received from numerous farm organizations, where streams have been so polluted by industrial waste or city sewage as to prevent their natural and lawful use for agricultural or other legitimate purposes."

Specific mention is made of conditions at Joliet, Ottawa, Seneca, Morris and Elgin. It is stated that the Desplaines and Illinois rivers are badly polluted and for years have been unfit for bathing or domestic uses, or for stock, and the fish industry has been completely destroyed as far down as Peoria. The stench at times in the summer is offensive and also a damage to navigation. Several States have laws regarding sewage treatment to avoid stream pollution. Such a law would be a progressive step in Illinois of a great public benefit."

The Mississippi river we have heard referred to as an open sewer. One will not allude to what other States are doing to it. It is enough to speak of the offenses against it in our own commonwealth. The Father of Waters must forsooth be forced to hold his nose when a whiff comes his way.

At Quincy, the sewage is emptied into the river above the city water intake, which, however, is far out in the channel. The sewage and factory waste of Moline, partially treated, go into the tail race and then into the Mississippi river channel at Rock Island. Rock Island pours the contents of its sewers into the Mississippi. The sewage and waste of the large city of East St. Louis are conveyed into the Mississippi river below the city. Alton finds the river a convenient receptacle for its waste and sewage. Cairo's sewage and waste pour into the Ohio and then into the Mississippi river. Other cities along both sides of the river from the north end of the State are abusing this magnificent waterway and contributing to its contamination. In low water the river is for weeks and even months likely to be a foul and filthy stream.

Tributaries that flow into the Mississippi river are polluted also. Take Rock River, one of the most picturesque rivers in the state, whose banks have been noted as picnic grounds. One of its tributaries is the Pecatonica river, and within the city limits of Freeport raw sewage flows into it in five places. This includes factory waste. Rockford, the main city on the river, known for the extent of its industries, turns its sewage into the river, and the report for Sterling, another good sized city, is of the same nature. All this sewage must tend to make the river less desirable and a menace. Belleville, not far from the Mississippi, uses a small creek for sewage in part, although it has a disposal plant. Shelbyville reported, "We are emptying everything into the Kaskaskia", and a similar answer came from Vandalia. On the other side of the State one finds Danville emptying its sewage into the Big Vermillion.

In nearly every case the reports make the statement that the rivers and streams are too foul to use as sources of supplies without treatment. In the state department report for 1919-20 we find this strong statement: "Stream pollution is depriving the public of the legitimate use of the water therein. For years streams not only in Illinois but in many states have been accepted as a natural means of sewage disposal. Increased develop-

ment and growth of population have resulted in a load of sewage or industrial waste that the streams can no longer carry with due regard to public health or to the use of the streams for stock on the farm". It is but simple justice to say that several of these cities are taking steps that may lead to the installation of disposal plants. Decatur and Elgin are leading the way, and my own city is agitating this question. One of the chief difficulties is in getting the people to vote the necessary funds.

In the 1923 report of the proceedings of the annual meeting of the civil engineers of the State is found an address by Paul Hansen who enumerates 103 disposal plants, and makes the comment that many of the plants are neglected, ten of them abandoned and eleven overloaded, disclosing that efficiency in many instances is far from maintained.

Thus is the run off from practically one-third of the rainfall, expedited by tiling and sewers, seriously affected, and the citizens of our State are being deprived of many billions of gallons of water annually. Cities are finding it increasingly difficult to find a stream of sufficient size to serve as a supply, when impounded, owing to the unsanitary condition which may extend even to the watershed.

Judging from the reports at hand it is the common practice of cities to create a reservoir on a stream and empty the sewage into the stream at some point below the reservoir. The next town below finds itself short of water and becomes aware that the city above is using the river for a sewer. But it builds its dam, and erects an extensive purifying plant, expecting that chlorine and other chemicals will protect the lives of the people, and in turn conveys its sewage to a point below its dam, thus contaminating the water for the next town below. This goes on for the length of the stream. The health of each of these places depends upon the efficacy of the purification plant, and any imperfection in this that causes raw water to get into the distributing system is likely to result in serious epidemics. Some of our Illinois cities have had sad experiences along this line. Pol-

luting a river for the city next below is a great deal like poisoning your neighbor's well. Cities that have deep wells or spring supplies are likely to show least responsibility. One might cite Rockford, Freeport, Peoria, Aurora and Joliet.

Illinois is not all equally favored. South of a line running east and west through Champaign, water, according to the 1914 Bulletin, is seldom obtained in large quantities either from deep rock or the drift, and such ground water usually is very hard. Some exceptions exist in Southern Illinois; but it is frequently the case that there is no choice but to adopt a surface supply in the south half of our State. This means the impounding of water, and this enhances the importance of maintaining the streams in an uncontaminated condition.

On the other hand many of the cities in the north half of the State are not obliged to resort to ground water due to the accessibility of deep rock supplies. These waters, as a rule, while fit for domestic uses, are not adapted to industrial purposes without treatment, due to the mineral content. Impounded surface water is generally much preferred and hence the large use of impounded water for boiler and other mechanical uses.

In the north part of the State two formations are recognized as fairly sure sources of supplies, and water may be found in others but not with the same degree of certainty. Sometimes it may be too heavily charged with minerals even for domestic uses. These two formations are the St. Peters and the Pottsdam. The former underlies much of six states and is regarded as one of the most remarkable water rocks in the world. Scores of municipalities procure their supplies from this formation, but the State reports indicate that constant pumping is gradually lowering the water level. The Pottsdam formation lies below the St. Peter's and is separated from it by the Lower Magnesium. Observation, however, indicates that the water level in this is also being slowly lowered.

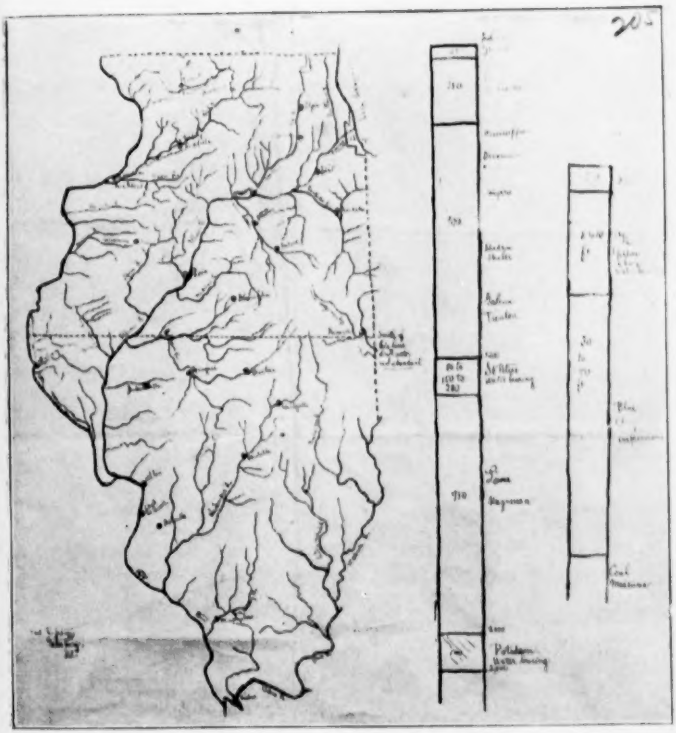
Thus there is raised the question whether these rock supplies are inexhaustible and whether finally a dense population will not even in the north part of the State

have to rely upon the surface and ground supplies; in other words on the rainfall. The question in view of the possible decline and the often quick exhaustion of the ground supplies in a dry season relates not merely to the preservation of the purity of the surface water but to its conservation.

Take Knox, my own, county. In it are 440 streams, little and big, enclosed between ranges of hills. Many of these streams could be dammed and the water preserved. We have built up a wonderful system of surface drainage that empties the surface layers of their water, more rapidly than formerly, and hastens exhaustion of the moisture so that crops suffer. Last year the drouth cost Knox county farmers a third of their corn crop. With reservoirs there could be at least partial irrigation. Even Congress has considered means of impounding water so as to prevent destructive floods. It is estimated that in Knox county, an annual rainfall of thirty six inches means the precipitation of four hundred and fifty billion gallons of water on its surface, and the immense run off of 150,000,000,000 gallons, if not more in flood years, goes on its way to the ocean, while during the dry season the beds of the streams may be dry. It goes without our making use of it.

Illinois has some good laws on the subject of stream pollution but in view of existing public sentiment it is difficult to apply them. For instance, the Statute provides that, "It shall be the duty of the Department of Public Works and Buildings to see that all the streams and lakes of the State of Illinois, wherein the State of Illinois or any of its citizens have any rights or interests, are not polluted or defiled.

"It shall be unlawful for any persons, firm or corporation to throw, discharge, dump, or deposit, or cause, suffer or procure to be thrown, discharged , dumped or deposited any acids or chemicals, industrial wastes or refuse, poisonous effluent, or dye stuff, clay or other washings, or any other substance deleterious to fish life, or any refuse matter of any kind or description containing solids, substance discoloring or otherwise polluting any navigable lake, river or stream in this state, or lake,



The state map in a general way shows the drainage system of Illinois and the cities that are the principal sources of stream pollution.

The deep well geological section shows the formations passed through in borings at Galesburg and vicinity that reach to the Potsdam. The other section is of the surface formations in Knox county, and with some variations will apply to much of the State.

river or stream connected with or the waters of which discharge into any navigable lake, river or stream of this State or upon the borders thereof, or any watercourse whatsoever." The drainage district for Chicago and the Desplaines river are made exceptions.

It was also provided by the Fifty-second General Assembly that it is necessary to submit plans and obtain a permit from the Division of Waterways before any work can be done legally toward the construction of a sewer outlet for the discharge of sewage into a lake, stream or water course of the State.

In all this I have been trying to show:

First—That under the present methods, ground supplies are not adequate the year around.

Second—That the usability of our surface waters represented by our streams is lessened by their pollution by sewage and factory waste.

Third—That the available supply could be increased by the suppression of such pollution and the enforcement of a law that would compel cities or permit them to provide for the disposal of sewage and waste. For the good of all, municipalities must be taught to observe sanitary law.

Fourth—That sewage and waste pollution of the streams is a menace to health, a source of disease, and renders water unfit for use, and constitutes a public nuisance, besides killing aquatic animal life and making the water a possible source of disease to domestic animals, which may communicate it to man.

Fifth—That conservation, checking flood waste, would probably carry the supply through the heated season and save much expense and trouble.

Sixth—That the uncertainty attending the life of deep well supplies makes the saving of surface supplies all the more important.

It seems to me that it would be well for us to urge the legislature to provide the State Water Board with an appropriation sufficient to enable it to make a comprehensive survey of the extent of pollution of Illinois streams and to formulate the most practical remedies. In the meantime, I believe that the systematic education

of the public should be undertaken and that they should become informed not only of the dangers of the indiscriminate use of our streams as open sewers and waste receptacles, but also of methods of conserving rainfall and making more of it available. It is a subject that could be pursued to advantage in our schools. Our streams should not continue to serve as cess pools, but should be converted back to their original state of wholesomeness.

COAL BALLS HERE AND ABROAD

A. C. Noé, University of Chicago

A coal ball is a calcareous or siliceous coal seam concretion which frequently contains recognizable plant fragments.* These plant fragments have furnished our entire knowledge of the inner structure of paleozoic plants. They have been observed since 1835 in England where Williamson used them in his monumental studies of fossil plants since 1875, a work which was continued by D. H. Scott in England, C. D. Bertrand in France, and many others.

The existence in America of coal balls was suspected by the author who succeeded in obtaining in 1922 the first specimens of genuine American coal balls. These came from Harrisburg, Illinois; later good specimens were found in Danville, Illinois, in Calhoun (Richland County), Illinois, and in Streator, Illinois. Other American deposits are in Iowa where coal balls showed up at DesMoines, Indianola, and Chariton. Good specimens were also collected by the author near Sturgis, Kentucky, and at Cayuga, Indiana. They were found outside of England, France, and America in Austria, Germany, Russia, Czecho-Slovakia, Poland, and Australia.

Of the American coal ball specimens from Harrisburg, Danville and Calhoun thin sections have been made in the botanical laboratory of the University of Chicago. The following genera of fossil plants were observed and their structure carefully examined:

Harrisburg—
- Sphenophyllum stem
- Lepidodendron stem
- Lepidodendron sporangium
- Stigmaria and rootlets
- Anachoropteris
- Angiospermophyton
- Root with spongy tissue
- Fern sporangia and spores
- Calamites leaf, probably in all three places.

Danville—
- Lepidodendron stem
- Lepidodendron sporangia
- Stigmaria and rootlets (few)
- Sturiella minor
- Fern sporangia
- Root with spongy cortex
- Peculiar leaf
- Calamites leaf

Calhoun—
- Sphenophyllum stem
- Calamites stem
- Bothrodendron stem
- Microsporophyll and sporangium
- Megosporophyll and sporangium
- Stigmarion rootlets
- Numerous multeseriate fern, sporangia with spores
- Lyginodendron stem

* Jose Maria Feliciano, *The Relation of Concretion to Coal Seams* (Journal of Geology, Vol. 32, pp. 230-239, 1924.

The results of these investigations are being published by Dr. G. H. Hoskins and Miss Fredda Reed in the Botanical Gazette. The most important of these discoveries was the appearance of a paleozoic angiosperm in one of the Harrisburg Coal Balls.* Among the unpublished material are several other angiosperm specimens which make the existence of angiosperms in the paleozoic beyond question.

Our entire knowledge of the inner structure of paleozoic plants has been based upon English and French coal balls. It is to be hoped that the American coal balls which have come under observation will contribute in the near future as rich material as was obtained formerly from England and France, and that our knowledge of plant structure will in this way be greatly enriched from American sources.

* J. Hobart Hoskins: *A Paleozoic Angiosperm from an American Coal Ball*, The Botanical Gazette, Vol. 75, pp. 390-399.

GLACIAL PHENOMENA IN THE VICINITY OF CARBONDALE

J. E. LAMAR, ILLINOIS STATE GEOLOGICAL SURVEY, URBANA

The area particularly discussed in this paper is that of the Carbondale quadrangle, in the northwest corner of which the town bearing the same name is located. This quadrangle may be roughly divided into three topographic units according to the bed rock formations which underlie these units respectively, as shown in the accompanying figure. The northern unit is that underlain by the Carbondale formation, composed of sandstone and shale, which when eroded, gives rise to a gently rolling surface. The central unit, which is by far the largest of the three, is underlain by the massive sandstones and shales of the Pottsville formation. This part of the quadrangle is very rugged and constitutes a portion of the Illinois Ozarks. Sandstone bluffs and cliffs are numerous. The southern unit of the quadrangle is that underlain by the limestones, shales, and sandstones of the Chester group. It has a varied topography. In places it is like the northern unit, and elsewhere like the central unit, particularly in the areas where some of the prominent cliff-forming sandstones are well developed.

The north three-fourths of the quadrangle drains to the north; the south one-fourth to the south. The northward drainage eventually merges in Craborchard Creek, which flows westward across the northern part of the quadrangle, but turns abruptly to the north in the northwest corner to join Big Muddy River.

The Illinoian glacier spread over the northern half of the region just described. It came dominantly from the north and perhaps a little from the east. The ice of the glacier was probably porous and much crevassed from the buffeting against the hills of the country over which it had passed, and its advance was seemingly very slow. The rapid melting and pronounced deposition which accompanied the formation of the terminal moraines of the Wisconsin ice were essentially missing. The melting of the Illinoian ice seems to have been comparatively slow. The ice moved over the rolling topography of the north-

ern unit of the quadrangle without great difficulty, but when it encountered the rugged upgrade slopes of the Pottsville unit, the forces which were pushing it ahead seem to have been insufficient to send it completely up the grade. The southward progression of the glacier, therefore, is thought to have ceased more because of a lack of motion of the ice itself rather than to the predominance of melting over ice advance. There was probably a geologically brief period when the advance and the melting back of the ice were equal and the margin therefore maintained a fairly constant position. During that time deposits accumulated at the ice front in thicknesses somewhat in excess of those formed elsewhere in this region, but in this rough topography did not form a prominent moraine.

The first important event in the general glacial history of the region was the shutting off of the drainage of Craborchard Creek from Big Muddy River. It is not known where the ice first interrupted the drainage of the creek, whether near Big Muddy River or farther up stream, but eventually the result was the same. All the precipitation as well as the water from the melting of the glacial ice was therefore ponded in that part of the valley of Craborchard Creek not occupied by ice and its tributaries until it became high enough to cross the divide at the headwaters of the creek some 20 miles east of Carbondale near New Dennison. Just how high the water stood in the valley can now only be approximated, but it certainly stood as high as 435 feet above sea level, for that is the present height of the New Dennison col. The maximum depth of the lake was about 100 feet. With the continued advance of the ice, certain northward flowing tributaries of Craborchard Creek were cut off from the main stream and became local lakes. Some of these lakes at times found exit across divides into neighboring valleys which still discharged into Craborchard Creek. Two cols which were produced in this fashion, but probably during the early stages of Lake Craborchard, occur in Secs. 1 and 2, T.10 S., R.1 E., where the waters of Little Grassy and Caney creeks probably crossed the divide into Sugar Creek and thence joined the main drainage.

During the existence of these lakes, deposition of materials from the melting ice was constantly going on. In the Craborchard lake, which was probably by far the largest on this quadrangle, it seems possible that unstratified gray clay accumulated in portions of the lake basin where deposition was continuous. From time to time boulders and pebbles fell from bergs and ice blocks floating about on the lake and became imbedded in this lake bottom clay. Thus it is possible that some of the gray clay till-like material which contains sparse pebbles may have originated. This method of origin does not, however, preclude the probability that the greater part of the gray till was formed in the commonly accepted fashion, but is merely a suggestion as to how a very similar sort of deposit might have been formed under special conditions.

In the smaller lakes and the larger lake alike there were deposited in considerable thicknesses statified materials composed for the most part of sand and silt. There is some gravel found with these sands and silts, but it occurs in lens-like deposits, some of which seem to have been built up as small deltas where comparatively rapid moving water entered a quiet body of water. In some of the smaller valley lakes in the central part of the quadrangle, fifty or more feet of these sands and silts accumulated. They are commonly underlain by pebbly clay till, and in places have this material intercalated with them. The valley of Sycamore Creek, in the eastern part of T. 10 S., R. 1 W. particularly, has excellent exposures of these sands and silts.

In two of the lakes the water seems to have become high enough to have spilled across the divide and found an outlet to the south to Ohio River. These lakes occurred in the valleys of Drury Creek and Little Grassy Creek respectively. The former lake had its inception when the ice shut off the drainage of Drury Creek from Craborchard Creek. By the time the ice had advanced south to a point about a mile and half south of Bosky Dell, the lake was about eight miles long and the water in it at that point was about 200 feet deep. The surface elevation of the lake was about 600 feet. Some of the

water spilled over a small col in Sec. 20, T.10 S., R.1 W., thence into Cedar Creek, and eventually into Mississippi River. The farther advance of the glacier, however, eventually shut off this exit and the water found its way across the divide to the south through a col just north of the town of Cobden. The elevation of this col is a little over 600 feet and drainage through it, and the previously mentioned col, may have been contemporaneous for a time. The Cobden col is not a particularly large col, its size suggesting that the quantity of the water passing through it at any time was not large. The col is cut in formations of the Chester group which are not particularly resistant to erosion. The character of the bedrock, therefore, would not have been a particular hindrance to the enlargement of the col had it contained a torrential stream. Glacial boulders have been found in the valley of Cache Creek south of the col, and though the presence of some of them doubtless may be assigned to transportation by human agencies, it is probable that most of the larger boulders were carried over the Cobden col in floating blocks of ice, and later left stranded farther down-stream.

It is a matter of interesting speculation whether with a head of 200 feet of water in Drury Lake some of the water of the lake may not have followed the natural trend of drainage to the north through the much crevassed glacial ice, eventually to find a mode of egress into the Mississippi or its tributaries; also, whether in places sedimentation may not have been going on within the body of the ice where it was saturated with water.

The lake in the valley of Little Grassy Creek was not as large as that in the valley of Drury Creek. Its maximum length was about three miles and it probably began when the ice blocked the valley in Sec. 19, T.10 S., R.1 E. The water in this lake stood at least as high as 570 feet above sea level. This is the present elevation of the Water Valley col over which the water from this lake found its way southward into Bradshaw Creek and eventually into Ohio River. The col is cut through a faulted area in which the Kinkaid limestone of the Chester group and a massive sandstone of the Pottsville formation are

exposed. The fractured character of the bedrock forming the floor of this col is a factor favoring rapid erosion. The col, however, is only about an eighth of a mile wide and does not itself seem likely to have carried a great volume of water, nor does Bradshaw Creek, into which the waters entered after crossing the col, show evidence of having carried an abnormally large volume of water.

Most of the materials which were presumably deposited in Little Grassy Creek lake have been eroded away, but in places in the valley a deposit of gray clay containing much rotted limestone boulders is found which was probably formed during the existence of the lake.

Very little outwash seems to have been developed in front of the margin of the ice after it had reached its maximum southern extent. Igneous boulders are found in places for distances of two miles or more south of the margin of the glacial deposits, but they are merely loose in the beds of the creeks and were not seen in any definite arrangement that could be considered characteristic of outwash deposits. The absence of these deposits is probably due to the rapid and pronounced erosion which has taken place since glacial times, and also to the tendency of the present drainage to transport the debris in the valleys to the north. Outwash boulders transported in this direction soon become mixed with other glacial material and are indistinguishable from it.

The retreat of the Illinoian ice seems to have been in a measure a replica of its advance in so far as the deposits which the ice left are concerned. Local lakes were formed in valleys, and Drury and Little Grassy lakes extended to the north until the ice ceased to obstruct the drainage in that direction. In these lakes more silt and sand accumulated, and elsewhere where water sorting was not active, a deposit of more or less heterogeneous materials.

To summarize, then, the outstanding features of the glaciation of the Carbondale quadrangle are as follows:

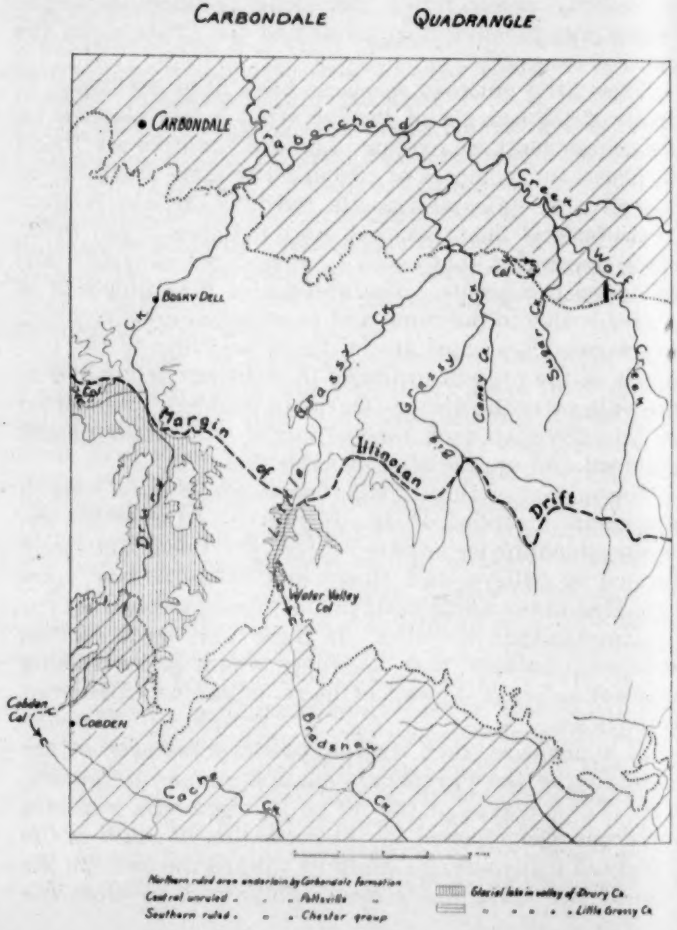
1. The advance of the ice to its maximum southern limit was accompanied by the formation of lakes in the valleys of many streams draining toward the ice. In the case of two lakes water rose high enough to cross the

divide of the Illinois Ozarks and to find an outlet to the south.

2. In these lakes were deposited primarily sand and silt. The silts are in some cases stratified, in others not stratified.

3. In an environment of such rough topography the terminal morainic deposits are not pronounced.

4. Outwash deposits are essentially lacking because they were either not formed or have been subsequently obliterated by erosion.



OUTLINE OF THE GEOLOGY OF THE OREGON QUADRANGLE[1]

ARTHUR BEVAN, UNIVERSITY OF ILLINOIS

Acknowledgment.—In the summer of 1923, under the auspices of the Illinois Geological Survey, the writer made a geological study of the Oregon quadrangle, a brief resume of which is here presented. A more detailed report will appear in the near future in regular bulletin form, published by the Survey.

Location.—The Oregon quadrangle comprises an area of approximately 235 square miles in the northern part of Illinois, about midway between Rockford, Freeport, and Dixon. It is mainly in Ogle County, but includes a narrow strip of territory in southern Stephenson and Winnebago counties.

Drainage.—Rock River enters the quadrangle at Byron, near the middle of the eastern border, and flows through the southeastern quarter of the area, past Oregon at the south margin. The well developed drainage of most of the area is directly tributary to this voluminous master river and its few large affluents within the quadrangle, with the exception of a few headwaters of Pecatonica River along the northern border.

Topography.—Dissection by the numerous streams has progressed until most of the area is in topographic late youth. The greatest dissection, which locally has reached a mature stage, is in a narrow belt on both sides of Rock River and throughout a broader belt along Leaf River, a comparatively small stream that flows easterly across the middle of the area to join the Rock a short distance below Byron. The greatest local difference in elevation is about 250 feet near Oregon, which is not much less than the maximum relief of approximately 300 feet for the entire quadrangle. The least dissection is in the southwestern portion, where an area of several square miles is still an undissected till plain.

Striking contrasts are exhibited in the topography of this quadrangle, and between it and that of much of the

[1] Published by permission of the Chief of the Illinois State Geological Survey.

surrounding territory. This is an area of advanced stream dissection in the midst of an expansive, slightly dissected till plain. Flattish upland rock ridges, thinly mantled with glacial drift, whose preglacial surfaces truncate the underlying strata, are present. Rock River flows for some distance in a youthful valley, locally a deep gorge, whereas Leaf River, its tributary of much less volume, occupies a mature valley in the same type of formations. Some other streams flow in places in broad open valleys but elsewhere their courses are entrenched in narrow rock gorges. A conspicuous topographic element, without homologue in this area, is a broad east and west depression, the Oregon Basin, in the vicinity of Oregon.

It is obvious from this brief outline of the salient topographic features of the quadrangle that its physiographic history has not been simple, but that the present surface has been produced by the successive action and interaction of several geologic processes. In brief, the present topography is dominantly that of surfaces stream-carved from rock of variable resistance and diversified structure, which throughout much of the area has been only slightly modified by deposition of glacial drift, with some conspicuous features due to drainage changes that resulted from the later invasion of the bordering territory by ice-sheets. Certain details have been impressed upon the major features by post-glacial activities.

Stratigraphy.—The rocks which crop out in this quadrangle consist of indurated sedimentary formations of the Ordovician system, and unconsolidated deposits of Pleistocene and post-Pleistocene age. The former range from lower to upper Ordovician, and the latter from Illinoian to the present. In descending age order the exposed formations are:

Recent: alluvium, dune sand, talus.
Late Wisconsin: valley trains, alluvium.
Early Wisconsin: alluvium, loess (?).
Post-Illinoian: loess.
Illinoian: till, fluvio-glacial deposits.

Upper Ordovician: Maquoketa shale.
Middle Ordovician: Galena dolomite.
Platteville limestone.
Glenwood sandstone.
St. Peter sandstone.
Lower Ordovician: Shakopee dolomite.

The oldest rock known by actual observation to underlie this part of the state is the upper Cambrian, or Potsdam, sandstone. It does not appear at the surface but has been encountered in a few of the deeper city wells.

Above the Potsdam sandstone is the Prairie du Chien series, which is commonly divided in this general region into three formations—Oneota limestone at the base, New Richmond sandstone, and the Shakopee dolomite at the top. The lower two formations do not crop out in this quadrangle. The Shakopee is exposed in a single restricted area on the crest of a sharp plunging anticline. Its most striking characteristic at this place is the number of sudden changes in lithology in the vertical succession of the beds. This can be illustrated by listing the principal lithologic types in the exposed 13 feet of the section. They are 1) dense, dull, platy limestone, 2) finely to coarsely crystalline limestone, 3) fucoidal limestone with poorly preserved fossils, 4) magnesian limestone, 5) cherty dolomite, 6) limestone or dolomite with well rounded grains of quartz scattered through it or segragated in irregular patches, 7) calcareous sandstone composed largely of the same type of sand, and 8) thin, variegated shales.

The well-known St. Peter sandstone is extensively exposed along the crests of folds in the vicinity of Oregon, and a few small outcrops are present elsewhere. It has commonly the same lithologic characteristics that are typical of it throughout the general region, but differs in some details, as, for example, the local concentration of iron.

Almost everywhere in this quadrangle the St. Peter is overlain by the Glenwood sandstone. This is a bluish-green rock composed in the main of fine, angular quartz sand through which is scattered a variable percentage of typical St. Peter sand grains. The persistent color and

distinctive texture make this formation an excellent horizon marker. A slight unconformity appears to exist at its base. A few miles east of Oregon the typical Glenwood is supplanted laterally by a series of beds, transitional between the typical St. Peter sandstone and the typical Platteville limestone, which consists of alternating thin limestones, ordinary sandstones, vermicular sandstone, clay, and shale. One section of these transitional beds is 40 feet thick.

The Platteville limestone crops out generally in the vicinity of Oregon, Byron, and Leaf River, where in the main low anticlines have been eroded. It is composed principally of limestone with a variable content of magnesium carbonate. The lower part of the formation can be identified readily by its buff color in natural exposures and its stratigraphic relations to the Glenwood and St. Peter sandstones. It is difficult in many places to distinguish the upper portion from the lower beds of the overlying Galena dolomite, especially if the outcrop is a small isolated one of beds not far from the contact of the two formations. There are, however, certain dependable contrasting characteristics by which most of the exposed beds can be confidently identified. A diagnostic feature is its content of fossils, which are more or less common throughout the formation, but are so abundant and of such variety at some horizons as to constitute a "fossil sea floor." Gastropods, pelecypods, and brachiopods are most common, with corals, cephalopods, ostracods, and trilobites somewhat less abundant to rare. Evidence has been discovered that the formation lies unconformably in places upon the St. Peter sandstone.

The Galena dolomite is the uppermost bed rock over the greater part of this quadrangle. Partial sections only are exposed in any of the outcrops, most of which are roadside or gully ledges a few feet thick, although continuous sections of considerable thickness occur in some ravines, gorges, and quarries. A diagnostic feature is the fossil *Receptaculites,* which ranges from a short distance above the base of the formation to well past its middle portion, with some horizons marked by its abundance. Other fossils are scarce, but locally the beds con-

tain numerous shell fragments or poorly preserved shells or imprints of shells. Much chert is present in portions of the formation, as scattered nodules along the bedding planes or in thin well-defined nodular beds. Certain strata are characterized by pores and pits up to a few inches across, which give rise to a rough, peculiarly fretted surface. Rusty calcareous sand, in separate particles or loosely adherent, partially fills most of the pits on weathered surfaces or throughout the fresh rock. In places these beds have disintegrated into a friable mass that resembles loosely cemented sandstone.

The youngest indurated formation is the Maquoketa shale, which occurs in this area as a single outlier on the summit of Bunker Hill, in the extreme northwestern corner of the quadrangle. About 70 feet of shale with intercalated thin beds of more or less fossiliferous limestone constitute the exposed section.

Beyond doubt the Niagara dolomite, which caps a series of hills to the west, formerly covered this area, but the last vestige of its outcrops has been destroyed.

The mantle rock immediately overlying the bed rock is very largely glacial drift, which is almost entirely of Illinoian age. No till of an earlier or later epoch is known to occur in this quadrangle. Some outstanding characteristics of the Illinoian drift are, 1) the large amount of gravel and sand in many parts of it, 2) the depth of leaching and oxidation, 3) its thinness throughout much of the area, and 4) the rough conformity of its surface in many places to the contour of the underlying bed rock.

The drift is not uncommonly a sandy and gravelly till. Large masses of stream-deposited gravel and sand are locally present in it. Numerous other large bodies of sand and gravel occur upon the surface of the till as kames and eskers. Both the included gravels and the superficial deposits are especially abundant in the Oregon Basin and in Leaf River Valley. The eastern portion of the largest esker in the state, the Adeline esker, is in the western part of Leaf River Valley in this area.

Since its deposition the till has undergone extensive chemical changes. It is deeply oxidized, and limestone fragments as well as the calcareous portion of the rock

flour have been leached from the upper several feet. That peculiar and distinctive product of long-continued weathering of till, gumbotil, is exposed in several places beneath the mantle of loess.

The maximum thickness of the drift in this quadrangle remains to be determined from a study of well records, but a striking feature of the area is the abundance of rock outcrops wherever slopes have been washed or gullied. In many places the bed rock is only thinly veneered with till, and on many ridge crests the present thickness of the till is not more than a few feet. Over much of the quadrangle the original thickness of the drift was not adequate to mask the topography of the rock surface, so that pre-Illinoian valleys and divides can be traced in the existing topography.

Borings show that the flattish uplands west of Rock River are underlain by loess to a depth of 15 or more feet. The thickness is much less on slopes, but this undoubtedly is due in large part to wash and creep during and subsequent to deposition of the loess. Traces of an old soil bed and fragments of vegetation are present between the loess and the underlying weathered Illinoian till.

The only recognizable deposit of Early Wisconsin age in this area consists of alluvium deposited in the eastern part of the Oregon Basin. It was made by streams that were blocked by outwash from the Early Wisconsin ice-sheet when it covered the region east of this quadrangle. Some of the loess may have been deposited during this epoch, but the amount is probably relatively insignificant when compared with the pre-Early Wisconsin loess.

The late Wisconsin deposits consist in the main of valley train material that partially filled Rock Valley and of alluvium that was deposited in tributaries which were blocked by the drainage down Rock River. Other streams have made their normal deposits up to the present time. Winds have whipped up some of the sand into low dunes in Wisconsin in recent times, and meager talus slopes have been formed along some of the cliffs.

Structure.—The structure of the formations in the Oregon quadrangle departs markedly in many places

from the simple gently dipping to slightly flexed structure which is generally considered to be typical of northern Illinois. Axes of sharp narrow anticlines with accompanying broad shallow synclines cross the area in a westerly to northwesterly direction. A characteristic feature of these anticlines is the narrowness of the folded zone and the steepness of the dips in this narrow zone. Gently dipping limestones will suddenly exhibit dips of 20° or more. In one instance the dip changes sharply from a few degrees to more than 40°. In another instance the St. Peter sandstone unexpectedly appears with steep dips, in the midst of gentle north-dipping Platteville limestone. Between these folds the strata are commonly only very slightly tilted or horizontal. These few examples indicate the character of the deformation in the Oregon quadrangle.

POT-HOLES AND CERTAIN FEATURES OF GLACIAL ABRASION

TERRENCE T. QUIRKE, UNIVERSITY OF ILLINOIS

Illinois and neighboring states are covered to a considerable extent by glacial deposits. These are subject to local examination and study. Investigation of the content of the drift shows that it is very largely of local origin, but that it contains a noticeable amount of material which has been brought from far beyond the local outcropping rocks. Some of the material has been brought from the northern side of the Great Lakes. In the areas of southern Canada one may see the glacial gathering grounds, stripped of their mantle rocks, exposed today almost in the condition in which they were left by the last ice sheet.

This paper has to do with certain phenomena observed in the Killarney area, a district on the north shore of Georgian Bay, the extreme northeastern corner of Lake Huron. This area is remarkable for the striking physiographic contrasts it displays. Early in the history of geological work in North America, the area was described briefly by Alexander Murray[1] in 1848. No one could pass this spot without seeing the great snow white quartzite hills, known as LaCloche mountains, rising above the hummocky granite plain which stretches with little interruption to the Laurentian highlands of eastern Ontario and Quebec. Here is a strange physiographic disconformity, the sudden end of a great range of quartzite hills, cut off transverse to their general line of extent by a lowland of granite. In general, we find the towering peaks of folded mountains to be of igneous composition, but in this case, we find the plains are granite and the hills sedimentary rocks. Examination shows that the quartzite formations are faulted, and destroyed by granite intrusions.[2]

ICE WORK

The major effects of glaciation which are common to most of the country north of Lake Huron are well illus-

[1] Alexander Murray, Exploration geologique du Canada, 1848, p. 113.
[2] R. Bell, Geol. Surv. Canada Ann. Report, Vol. IX, 1898, pp. 8-9. A. E. Barlow, Geol. Soc. Am. Vol. IV, 1893, p. 315-321.

Fig. 1. Pothole and glacial grooving on shores of Lake Huron.

Fig. 2. Solution potholes in granite near MacDonald hotel, Killarney.

trated in this area. The highest peaks have been glaciated, indicating that the ice was at least 1200 feet in altitude above the present level of Lake Huron. The lowlands are polished and stripped to the bed rock in most places, so that the granite plain is hummocky with the roches moutonnees so characteristic of glaciated countries, with small swamps and ponds in the intervening depressions.

Along the lake shores the minor effects of ice erosion are well exposed. Deep grooving both above and below water level is strikingly developed on the northern shores of some of those islands which are composed of dense, fine grained granite gniess. (Figure 1.) This sort of abrasion on a larger scale has greatly modified the shape of the shore line, especially in such places as the south shore of Philip Edward Island, and the mainland and fringing islands east of Beaverstone Bay, where the structure of the rocks is parallel to the direction of the ice movement. In many places small and giant chatter marks are common.

Chatter marks are concave towards the direction from which the ice came, and they are on the stoss side of the roches moutonnées. There are also certain breaks which are the opposite of chatter marks; they are on the lee side of the rocks, and they are concave toward the direction in which the ice was going. They are not true features of plucking because they do not follow apparent joint planes, nor are they controlled by them. They appear to have been formed much in the same way as giant chatter marks, except that they are on the upper part of the lee side of the rocks, and that they are concave in the opposite direction to that characteristic of chatter marks. They break away on the lee side apparently because there is a breaking face on that side. The reason that chatter marks are scoop shaped is because there is no vertical breaking face, and the plane of fracture returns to the surface, which is the only available breaking face.

The granitic rocks are pitted with shallow depressions in many places after the fashion of pot-holes.[3] (Figure 2.) Pot-holes are usually thought of as those depressions which are worn by swirling boulders or pebbles

below the falls of a rapid river or in other eddying streams, but the great abundance of concave surfaces on the Killarney granite and gneiss makes any reasonable observer at once give up any such explanation for the thousands of "pot-holes" in this district, unless indeed he believes that the whole area was at one time overflowed by a huge and very widespread torrent. Streams doubtless followed the glacial period, but such an explanation does not fit all the cases because many of the depressions have the smooth, polished surface characteristic of glacial polishing. Many of these depressions antedate the last glacial sheet which covered the land. Observations show that a variety of causes has brought about similar products in different manners.

The granite at Killarney has a nearly horizontal sheeting. It tends to break off in rather irregular and shallow slabs of rock as a result of frost work. Glaciers riding over these granite surfaces broke out some of these slabs and carried them away. The place left, in several cases found, is almost scoop shovel shaped. (Figure 3.) The glacier chipped out a piece of rock, which broke in a vertical direction down to the sheeting plane in a curving surface which was convex toward the direction from which the glacier came, provided the breaking surface was on the sheltered side of the rocky knob or roche moutonnée. In some other cases the granite broke out from the bed rock on the downstream (stoss) side of the outcrop, concave towards the direction from which the ice was coming, as a sort of giant chatter mark. In either case, the passing ice in time smoothed off the edges of the broken rock, and left a polished depression in the midst of an otherwise convex surface, looking something like a pot-hole. (Figure 4.)

In other cases the primary depression was made by the conjunction of three or more joint planes which loosened upwards a piece of rock of pyramid shape. After frost had heaved this piece loose, and passing ice had carried it away, the place from which it came provided the start of another polished depression which looks like a pot-hole. Near Killarney these joints were

[3] Pot-holes have been described and classified in detail by E. D. Elston. The Scientific Monthly, Vol. V pp. 554-567 and Vol. VI pp. 37-51 (1918).

Fig. 3. Potholes due to removal of granite sheeting slabs.

Fig. 4. Glaciated depression made by intersecting joints.

Fig. 5. Concave fractures of Killarney granite.

Fig. 6. Solution cavities in pegmatitic granite.

found to have the following positions; strike N. 180° E., dip 40° W; strike N. 15° E., dip 39° S; and strike N. 85° E., dip 87° S. A similar process is responsible for some of the so-called rock "tanks" in arid regions[4].

Again it happens that the Killarney granite has a natural conchoidal fracture in some places, and (Figure 5) under any stress, such as that, for instance, of a passing glacier heavily loaded with locally burdensome drift, it is likely to break along curved surfaces. A piece which breaks out of a plane face naturally leaves a concave surface, and after such a surface has been glaciated, that too is like a pot-hole.

There are porphyritic phases within the granite and the gneiss which are not of the same fine, even grain characteristic of the rest of the rock, and the parts which are weaker than others weather more readily and leave hollows in the surface, which are likely to have been smoothed off by glaciation. (Figure 6.)

In the side of a nearly vertical surface facing northward, on the north side of an island south of Philip Edward Island, there is a cavity, over a foot deep, which penetrates a glaciated surface, and which seems to be in part of age greater than the last ice sheet. This hole is gradually growing larger by a sort of spherical scaling within the hole. The hole is growing on opposite sides of a narrow crack in the rock. The crack appears to be the thoroughfare by which ground water works into the rock, oxidizes the minerals, and causing them to expand in volume, creates a pressure sufficient to crack the rock. The shape and position of the hole is such that pieces which break off fall out of the hole into the lake; thus fresh rock is repeatedly exposed to the agency of disruption. Of course this is not a pot-hole, for it is quite impossible for a pot-hole to form in the side of a vertical cliff, yet it is a hole, and after glaciation such a hole would be distinguished with difficulty, in some situations, from a real pot-hole made by swirling boulders. (Figure 7.)

[4] Kirk Bryan, U. S. Geol. Surv. Water Supply, Paper No. 498, (1923), p. 43.

In the immediate neighborhood of Killarney, in the village itself, one may see all but the last type of glaciated rock hole. At the rocky point, at the west end of the channel, on the north side of the water, one may see the depressions formed by two types of giant chatter marks. In the walk outside the MacDonald Hotel one may see the depressions formed by the intersection of joints, and by the conchoidal fracture of Killarney granite, and there are excellent illustrations of the way in which the glacial abrasion truncated and partly destroyed some depressions which had been made at an earlier time. Only those which came in the later period of glaciation are preserved intact. In a garden near the store of Mr. T. Jackman there is a rock exposure which shows admirably the way in which some of the pegmatitic and miarolitic material in the granite weathers into pitted shapes something like pot-holes.

A significant argument that the pot-holes are indigenous to the granite and not the result of any outside agency is the fact that the quartzites of the same district contain almost no such depressions. Photographs show the peculiar shape of the glaciated surfaces of the granite rock moutonées. Almost all of these peculiarities are due to a normal glaciated surface, which is convex upwards in the direction of glacial movement, truncating a smooth surface which has been glaciated, although not fashioned by glaciation, and which is concave upwards. Some of these concave surfaces were in existence before glaciation, some came into being during glaciation, and others came after glaciation. (Figure 8.)

Thus it is stupid to suppose that all concave surfaces, or even holes, in glaciated rocks are due to the work of subglacial streams. It is quite clear at Killarney that several other agencies made such depressions, and there is no evidence that any of these "pot-holes" were really made by the spinning and swirling of boulders caught in an eddy of a subglacial stream or at the bottom of a moulin in a glacier. Striking as these holes are, they do not seem to have been bored by any natural gimlet, such as a spinning boulder in running water. Indeed, this area provides the evidences of "pot-holes" of hitherto undescribed methods of development.

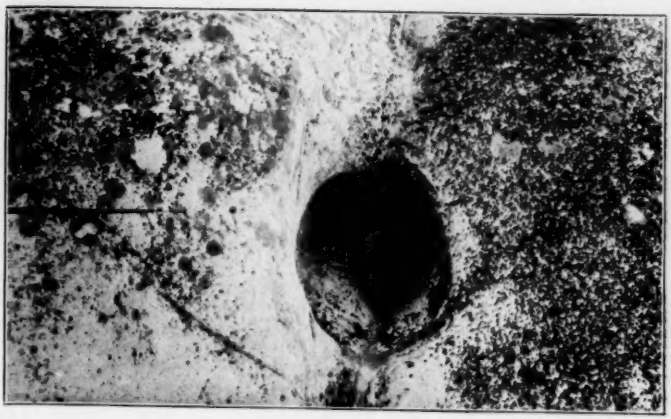


Fig. 7. Cavity in granite due to spheroidal weathering.

Fig. 8. Concave surfaces of glacial erosion, simulating potholes.

SOME QUESTIONS IN GENERAL AND PETROLEUM GEOLOGY WHICH ARE SUGGESTED BY OIL OCCURRENCES IN CRAWFORD COUNTY, PENNSYLVANIAN BEDS

JAMES H. HANCE, STATE GEOLOGICAL SURVEY DIVISION, URBANA

SUMMARY

Over a considerable part of Crawford County, oil production from Pennsylvanian sands is conditioned by other factors, perhaps as important as the LaSalle Anticline. Certain features indicate a nearby source for the oil and this may be important in future exploration work.

GENERAL

One of the controlling features, perhaps the most important, of the oil fields in southeastern Illinois is the LaSalle Anticline which extends from the vicinity of LaSalle southeast nearly to the Wabash River at St. Francisville. Productive territory has been developed through Clarke, Crawford, Lawrence, and Wabash Counties for a distance of seventy miles, and although this area of production varies in width up to sixteen miles, commercial accumulation of oil extends to a distance of eleven miles northeast from the axis on the less steeply dipping flank.

Thus far production has been developed from Pennsylvanian sands on down to the Trenton limestone, but the development in any one place is limited to a small portion of the vertical range. (Martinsville area excepted.) Thus in Lawrence County most of the oil produced comes from rocks of Mississippian age. In Crawford County production is chiefly from Pennsylvanian and Mississippian rocks, and in Clarke County, the Pennsylvanian, Mississippian and Ordovician rocks are each important locally.

All of this production is along the LaSalle anticline and is clearly related to it. During the past eight years detailed studies have brought to light certain features, which when better understood may assist greatly in

further development. In 1915, Rich[1] made a careful study of the Birds Quadrangle in Crawford County, and noted the allignment of the Pennsylvanian sand production at right angles approximately to the axis of the anticline. He concluded that the Pennsylvanian beds were essentially flat-lying over this area, and that oil accumulation in the Robinson sand seemed to be conditioned on its thick and massive development. Differences in elevation of the sands due to arching and folding are less in amount than differences due to irregularities in the sand lenses themselves.

Later work by Mylius[2] in Clarke County disclosed certain features in the northern part of the field, to account for which he hypothecates cross folding. As some of the production includes pre-Pennsylvanian rocks, the problem is modified somewhat, but the fact is noted that something other than the LaSalle anticline is involved in the oil occurrences in this part of the field. Recent field work, as yet incomplete, in the north one-half of Crawford County is adding its quota to the information relative to our south-eastern oil fields and furnishes some conspicuous contrasts between Pennsylvanian and pre-Pennsylvanian production. Here the upper sands (Robinson) are elongated in a direction approximately N. 52° E, whereas upper Mississippian production (Chester), developed here in only a small way, follows the direction of the anticline. As noted by Rich in the Birds Quadrangle, differences in elevation of the top of the Robinson sand are influenced less by folding and warping than by lensing. Some of these areas are irregular in shape with no conspicuous or symmetrical elongation. Others are several miles in length, and these longer dimensions are in the northeast-southwest direction. Another noteworthy feature is the occurrence of all of these elongated areas on the northeast side of the axis of the anticline. In no instance have they been reported or observed on the west flank of the fold. The most prominent development of this nature occurs between Birds and Annapolis, a distance of about twenty miles.

[1] Rich, J. L., Oil and Gas in the Birds Quadrangle, Ill. State Geol. Survey, Bull. 33, pp. 105-145.
[2] Mylius, L. A., Extract from Bulletin 44, Ill. State Geol. Survey.

Summing up the observations to date, we have the following:

1. Robinson sand production is commonly elongated in a northeast-southwest direction. This does not hold true for the Chester. Perhaps correlation is at fault.
2. These elongated areas are all east of the fold, but are found very close to it.
3. The sand top drops less rapidly from west to east than to the north or south. Available data, though too meagre to be very satisfactory, indicate overlapping sand lenses.

QUESTIONS

Since these occurrences are somewhat independent of the general structural conditions along the LaSalle anticline, they raise some interesting questions.

1. Are these transverse elongations due to cross folds, faults, sand lenses, or some other agency?
2. Why are they confined to the east side of the anticline? Perhaps the final solution will show that they are not so confined.
3. Are they limited in occurrence to the immediate vicinity of the anticline, and if so, why?
4. Do these occurrences suggest certain phases of Paleogeography? What are some possibilities?
5. What and where is the probable source of this oil? Is it local or may it be remote? Has any of the oil migrated very far?
6. What is the general artesian circulation of the Illinois basin? Is there a critical relation between the oil accumulation and the present artesian circulation through the basin? If so, what?
7. How are these questions related to future exploration?

SOME TENTATIVE SUGGESTIONS

At present studies are too incomplete to answer finally most or all of these questions, but some points seem reasonably clear.

Cross folding is not apparent here because the sands appear to be missing where the synclines should be found. Contours on the top and the bottom of the Robinson sands

would be at variance. Is cross folding known to occur anywhere?

Displacement or faulting of the sands does not seem to be shown from a study of the well logs. This hypothesis, however, is not untenable so far as the writer knows. Sufficient confirmatory evidence is lacking.

A study of the well logs indicates the existence of elongated sand lenses and bodies. This material is somewhat variable, and shale or lime breaks are commonly reported within such sand bodies.

Studies of present development fail to show these transverse zones on the west side of the anticline, although recorded dry holes indicate a fairly thorough testing of the west flank. The Pennsylvanian beds are more nearly flat on the east flank than on the west. Perhaps this is sufficient reason either for occurrence of the sand lenses or for their gathering oil. Only the higher portions of such sand lenses might favor commercial accumulation of oil, and hence the importance of a position near the crest of the anticline. Do these sand lenses indicate near-shore phases of Pennsylvanian geography? No fossils from them are available for study, but the interspersed limestones are marine. This is demonstrated by a study of samples from outcrops and from diamond drill cores. Were the sand lenses formed as off-shore bars, beaches, dunes, river channel fillings, or composites on a delta? Rich favors the delta hypothesis for the Birds Quadrangle, and it seems in harmony with conditions to the north and northwest of that area. If this were the case, was the shore line parallel approximately to the LaSalle anticline as has been commonly supposed? Did a large river discharge its debris into the sea in or near Crawford County, and in what direction did it flow?

Some differences of opinion are held as to the probable source of the oil, but greater favor is now accorded the idea of a local source and of limited migration to the present sand reservoirs. Abundant organic material was present in the muds (both lime and siliceous) at the time of deposition, and only a small fraction of this would be needed to furnish the amount of oil now known to have been present. Most of the geologic section is made up of

shales and limes, and as most if not all of these were marine, the local supply of organic material was perfectly adequate.

Present conceptions of artesian circulation, in a basin such as our Illinois Paleozoics form, favor the idea that marginal movements are much more rapid than are those in the deeper part of the basin. Such circulation doubtless has been changed many times since the Illinois Paleozoics were deposited as rock debris, but most of this circulation has probably moved southward. During Pennsylvanian time the LaSalle anticline formed a structural high, along both sides of which there may have been relatively rapid movement of meteoric water. If not too rapid this would favor oil accumulation in suitable reservoirs. With an oil content in some of the shales of 12 to 16 gallons per ton[3] the adequacy of material is no problem. If this hypothesis should prove correct, the oil now developed is local in origin and large areas to the west of the fold may justify test drilling where structural and textural conditions can be determined as favorable. Similarly, reserves in the Mississippian and lower rocks were developed under physiographic conditions unlike those of the Pennsylvanian, and for obvious reasons may be expected to conform more closely to the larger structural features.

[3] Ashley, G. H., Bulletin 641, U. S. Geol. Survey, pp. 314-319.

THE SOUTH AMERICAN INDIAN AS A GEOGRAPHIC STUDY

WILLIAM H. HAAS, NORTHWESTERN UNIVERSITY

South America offers many surprises to the traveller, but none of them is more arresting than those which relate to the Indian. He gives an atmosphere to the west coast countries which has no counterpart anywhere. At first sight of some of the world's famous ruins, such as Sacsahuaman, Ollantaytambo, Tiahuanaco, and others, there comes an almost irresistible conviction that the builders of these tremendous structures with their huge blocks of stone were of a better blood than that of the modern Quechua or Aymará with his sullen and hopelessly sad hang-dog expression. Nevertheless, the near ancestors of these spiritless people were a part of the proud and powerful Inca Empire.

The contrasts between a brilliant past and a sordid present is in constant juxtaposition. The resourcefulness of the ancestors, their activity, application, and conceptions of big things are everywhere as evident as the filth, the poverty, and the degradation of the descendants, making the contrasts all the more striking. It is hard to believe that living in the same general physical environment in contact with a superior, at least a more advanced race, should have produced such a marvelous change in such a remarkably short time.

It is not surprising, therefore, that for many years the belief existed among most investigators that the Incas, the Chibchas, the Mayas, the Aztecs, and our own Mound-builders were of a different racial stock than that of the Indian of today. Little by little, however, an overwhelming mass of evidence has accumulated, which shows that all belong to the same stock, and that practically all their cultural evolution, as shown in major and minor antiquities, has taken place in the New World. This has been done in a comparatively short time, for we have no undisputed evidence of glacial man in America. Various evidences tend to show that the American Indian came to this continent shortly after the stone polishing stage had been inaugurated in the land from which he came.

To the student of geography these facts are interesting and vital, for this means that the progress evolved in the New World has been, very probably, as distinct from any Old World development as though it had originated on another planet. The Indian is a product, therefore, of the American environment, and the differences in advancement can be explained only by the differences in the natural conditions which made certain advances possible. A study in this field ought to be productive in working out fundamental geographic relationships, which here should be found in their simplest forms.

The field of investigation, however, is not an easy one, for much is still unknown. The student of geography needs to know, rather definitely, how much of the development of this culture was accomplished under the Asiatic and how much under the American environment. What cultural elements did this migrant bring with him on which to start? Have all the cultural elements of both continents come from the same or from different groups, or migrations? After their arrival on these shores, did their dispersal come at once before a local development had taken place, or was the dispersal due to slow spreading from the periphery of the group? Can certain similar elements of culture originate simultaneously in far distant places, or when such are found, may they have been transmitted by contiguous groups and may they be traced to an original center? These and a host of other questions must be answered before the Geography of the American Indian can be written.

The non-Anglo-Saxon sections of the New World offer by far the best conditions for such study. Even in the regions north of the Rio Grande much still can be found out concerning the life relationships of the American Indian, but it is to be regretted that so little attention is paid along lines of investigation where facts readily attainable now will disappear most probably in this generation. However, in South America the general lack of white development in many sections offers possibilities of study entirely unknown here, for even now some of the countries are more Indian than white.

When one speaks of the American Indian in South America, it becomes necessary to explain the term used.

In the Indian countries little or no distinction is made as to blood relationships. The distinctions arise from the great contrasts among the people in wealth and social position, and are very sharply drawn. To find statistics on the "Indios" or "Mestizos" does not mean Indians or mixed bloods but merely those of the lowest and next lowest rank, those without wealth and social position. Anyone with sufficient leisure, who can maintain his family without work, belongs to the white class. Possibilities of change from one class to another are rare, as opportunities for the accumulation of wealth by the poor are few. A class division, therefore, may be made, into one with opportunities and into one without hope. The latter group for want of a better name may be called Indian.

Mixing of bloods has gone on without any sentiment against it ever since the time of the "Conquistadores", so that there are, very probably, few native whites without some strain of Indian blood, and likewise few Indians, except in some of the undeveloped sections, that are free from admixtures. The number of pure blood Indians in the plateau countries is much greater than pure blood whites. The Bolivian census for 1900 gives the Indian population as 48.42 per cent of the total and the white as 14.64 per cent, the rest being mestizos. These figures representing classes may be fairly correct, but the absolutely pure white population is probably less than two per cent of the total. The figures show, however, the dominance of the Indian blood in the life of the Republic.

If there is such a thing as cultural evolution controlled or modified, at least largely, by the environment, then there should be such a thing as regional cultures brought about by regional activities,—in other words, a regional geography of the American Indian. South America has been divided into four major cultural areas on the assumption that the activities based on the getting of food are the most fundamental. These culture groups are as follows: (1) the Chibcha in Colombia, agriculturists of the upland type; (2) the Manioc in the Amazon basin, agriculturists whose main food was the roots of the mandioca; (3) the Guanaco, in the Pampas of Argen-

tina, hunters whose activities were much like those of our plains Indian; and (4) the Inca, on the high plateaus of Peru and Bolivia, agriculturists whose progress far outstripped that of any others.

If such a classification is legitimate from a geographic point of view, then the geographer has a large field before him and some serious problems. Why was the evolution so slow here even in the most progressive sections when compared to Old World development? It seems incredible that the Indian lived here without much progress while civilizations in the Old World rose and fell. The natural environment of the western world, for the most part, seems to be stimulative enough now. Climate and topography were then much the same as now. The available resources, of course, are immensely greater now than then, and probably will continue to multiply as methods are discovered to use the resources locked up for the present. Were the migrants a dullard group, driven from their old environment by the more progressive and thus in their wanderings reached a new world? The evolutionary trend has not been in that direction, for many a full blooded Indian has shown great brilliancy along certain lines.

Whatever the geographer of the future will find, one of the most striking facts is that the descendants of that most advanced group, the Incas, are at present in the most pitiable condition of any group in either continent. Their poverty is great, with little or no possibility of changing their status under present conditions. This is not due to laziness or lack of energy, but largely due to a vicious system in which they find themselves. Their condition is well nigh hopeless and if they have a philosophy it is one that accepts the inevitable. Their "chicha" is their curse as it undermines their physical and moral welfare. It is also a blessing in that it enables them to forget a sordid world and to conjure up a new one with hope. Their "coca" dulls their minds and sensibilities and makes of them little else than a beast of burden. However, it also dulls the gnawing pains and the recollections, if there are any, of ancient splendor. The environment is powerless now to stimulate for there are other forces which dominate.

PALEOZOIC KARST TOPOGRAPHY

GEORGE E. EKBLAW, STATE GEOLOGICAL SURVEY

Karst topography is that unique physiographic expression which is characterized by surficial sinks, "lost" rivers, natural tunnels or bridges, subsurface solution channels, and subterranean caverns. The name "Karst" was applied because of the remarkable development of this type of topography in the Karst or Carso plateau of Austria.[1]

Since it results from solution, karst topography can occur only in areas that are closely underlain by thick beds of limestone, dolomite, gypsum, salt, or other soluble rock formations. Most of the known areas of karst topography are underlain by limestone or dolomite. Many karst areas occur in the United States and other countries.

In many localities, such as northwestern Illinois and southwestern Missouri, valuable mineral deposits have been described as filling ancient solution channels and cavities. This is indirect proof that karst topography existed in geologic periods other than the present. Unique and direct evidence of this fact was obtained last summer in the vicinity of Kankakee, Illinois, which area is underlain by Niagaran limestone or dolomite at a very shallow depth.

In the quarry of the Lehigh Stone Company, seven miles west and one mile south of Kankakee, are "clay pockets" which on examination proved to be deposits of shale in cavities that are clearly fossil sinks. All of the cavities have the shape of a funnel or a cone with the apex downward. In some of them the walls have a gentle average slope; in others they are precipitate. Again, regardless of the degree of their slope, the walls have a constant and consistent pitch from top to bottom, or they may be made up of alternating projecting and receding layers when the slope is precipitate or of alternating pitches and flats when the average slope is gentle. Except where the wall has collapsed before or during deposition of the shale, it has gen-

[1] Sanders, E. M., "The Cycle of Erosion, in a Karst Region (After Cvijic)", Geog. Review, v. 11, No. 4, p. 593-604, 1921.

erally a smooth surface, which is apparently the result of solution. In size the cavities vary from ten to a hundred feet in diameter and from twenty to forty feet deep, and their outlines may be circular, oval, or irregular. They are not arranged regularly relative to one another, but they do show a rude parallelism, controlled probably by joint-planes where solution would be favored. Occasionally two or more cavities may be so close that their upper portions coalesce to form one large pit with several separate downward projections. Along the joint-planes are many smaller vertical tubular solution channels, also filled with shale.

The shale which now fills the cavities is of two general types. The more abundant type is usually light greenish-gray, non-laminated, silty, and contains much crystalline iron-sulfide. It also contains rounded pebbles of limestone and chert. Frequently it is laminated, in which case some of the laminae are either fine, gray sandstone, or thin, black layers of carbonized plant fragments. Rarely the laminae are of variegated colors of purple, blue, green, and gray. This shale has a sub-conchoidal fracture; it weathers rapidly to a non-plastic, non-tenacious silty, gray mud. It fills all the cavities except that portion in each of a few of the larger ones which is occupied by the second type. The second and less common type of shale found in these cavities is black, laminated, carbonaceous, full of carbonized, well-preserved plant fragments and brown spore-cases or seeds, and with an abundance of botryoidal nodules of iron-sulfide that are of all sizes up to about three inches in length. When fresh, this shale has a conchoidal fracture that continues across several laminae. It weathers rapidly on exposure, first dividing into sub-conchoidal, lamellar flakes and then further disintegrating into a black, non-plastic mud. Two or three showers with intermissions of but a few days afford sufficient opportunity to reduce the fresh shale to mud.

Where both types of shale occur in the same "pocket" there is a sharp line of contact between them, and the green shale contains weathered masses of the black, indicating decisively that the green is younger than the

black shale and that there have been at least two separate generations of sinks in this one area. In addition to these two types of shale, there are rare occurrences of a granular, fine or coarse grained, calcareous sandstone that is made up of grains of quartz and of the surrounding limestone. In several cavities there are deranged masses of limestone that are collapsed portions of the walls, and around these masses the shale is practically undisturbed from its horizontal position, showing that the collapse occurred contemporaneous with the deposition of the shale. Similarly, where there are irregularities of the walls or recessive channels, they are filled by shale that is stratigraphically continuous with that in the main pit.

Some idea of the extent of the area which exhibits this phenomenon may be gained from the following facts. The Lehigh Stone Company abandoned an old quarry two miles west of the present one because of the prevalence of "clay pockets". While testing prospective areas on which to locate the present plant, they found similar "clay pockets" abundant over a wide expanse of this region. In an old quarry on the west side of the Kankakee River at Kankakee it is reported that there were found "soapstone pockets," which are doubtless the same as the usual "clay pockets", containing good shale. Several of the farm wells in the intervening territory have been drilled through "mud" for many feet instead of the usual rock, and this fact, considered in the light of the chance location of well sites, indicates that the shale-filled cavities must be numerous, to say the least.

In the eastern part of Bradley, two miles north of Kankakee, are two small circular swamps overgrown with willows, which probably mark the location of large shale-filled sinks like the others. Dr. D. J. Fisher of the University of Chicago reports that in the quarries about Joliet are similar cavities filled with green clay or shale, but there the evidence was insufficient to warrant any positive statement as to their origin or age. Smaller cavities in the Niagaran limestone, filled with Devonian shale or clay, have been reported from a quarry near Elmhurst[1] and from McCook, near Summit[2].

[1] Weller, Stuart: A Peculiar Devonian Deposit in Northeastern Illinois; Journal of Geol., v. VII, No. 5, 483-488, July-August, 1899.

[2] Personal communication from G. W. Hawley, State Geological Survey.

There is no reason to believe that these cavities are anything but sinks; every geologist who has seen them agrees to that. The only other possible explanation is that they are pot-holes, but their shape disposes of that possibility without argument. Their age can be determined from the deposits that fill them; all geologists who have examined them believe that the green shale or clay and sandstone is Pennsylvanian in age, but the age of the black laminated shale is in doubt. An authority to whom the material was shown has suggested that it may be Devonian; another, that it may be Pennsylvanian; but neither of these has yet had opportunity to study the deposits or the plant fossils sufficiently to make a definite statement. The color of the shale and the occurrence of Devonian shale in cavities in the Niagaran limestone near Chicago tend to strengthen the possibility of Devonian age. If it proves to be Pennsylvanian, the marked difference in character of the two shales and their abrupt contact where they occur together are ample proof of two distinct epochs of deposition.

Two hypotheses may be offered to explain the conditions under which the sinks were filled by shale. One is that after the sinks were formed the outlet at the bottom of each became choked and the pits gradually filled up with material washed into the resulting ponds by surface run-off, in which may have been included much organic debris. The possibility that some of the debris is the residue of plants growing in the sink itself is untenable because the shale is in horizontal layers as is found only in subaqueous deposits, shows no old soil or peat or coal, and contains no plant remnants in place. The other hypothesis is that the area was completely submerged beneath the sea, and there filled with silt, sand, and organic debris. The regularity of the deposits seems to indicate the latter hypothesis the more probable, in which case the abundance of plant remnants indicates that the area was near the shore of that sea.

It is safe to state that at some time after the deposition of the Niagaran limestone or dolomite in the Silurian sea over this area and preceding either the Devonian or the Pennsylvanian period, there was relative emer-

gence of sufficient relief to permit ground water to develop subsurface channels and caverns with surficial sinks. Then there was a complete relative submergence, during which the sinks were filled with black shale, but whether this relative submergence was of Devonian or Pennsylvanian age must yet be determined. A second relative emergence permitted the development of a second generation of sinks, some of which were formed in the rock forming the walls of those developed during the first emergence. A second relative submergence, undoubtedly Pennsylvanian in age, provided opportunity for these sinks in turn to be filled, this time with a green shale.

Since that time there have been relative emergence and subsequent erosion of such overlying formations as may have been deposited, bringing the area to its present altitude. So far as the writer is aware, modern or Pleistocene karst topography nowhere occurs on the Niagaran dolomite, although its altitude would seem to permit such occurrence; in Paleozoic times there were two distinct periods or epochs when a youthful karst topography was well developed in the same formation. Whether this is due to a decrease in the solubility of the Niagaran dolomite or to some other cause is at present a matter of conjecture.

AGRICULTURAL ADJUSTMENTS TO THE NATURAL ENVIRONMENT IN SOUTHEASTERN MINNESOTA DURING THE PERIOD OF BONANZA WHEAT FARMING

CHARLES C. COLBY, UNIVERSITY OF CHICAGO

The period of bonanza wheat farming in southeastern Minnesota covered approximately the two decades from 1860 to 1880. During all of this period the wheat crop constituted the principal economic activity in the area, and during much of it the counties in this part of Minnesota were the leading wheat producing counties of the state. Peculiar interest attaches to the development and decline of wheat culture on a single crop basis in southeastern Minnesota, because this area was one of the first, if not the first section of the present spring wheat area to be settled and it, therefore, pioneered in spring wheat farming. To appreciate the rapid rise of bonanza farming in the area, it must be remembered that southeastern Minnesota was opened for settlement in 1853, and that in the ensuing four years most of the land within a two days' haul of the Mississippi was occupied. The area, therefore, was settled and considerable of it was under cultivation before 1860. Thus settlers in the area were in a position to be benefited by the high prices for wheat and other farm products which prevailed during the Civil War. Of the crops grown, wheat shortly proved to be the most profitable because it commanded a high price, it produced abundantly on the fertile upland prairies, it was grown with a relatively small amount of labor, and it shipped satisfactorily via the existing means of transportation to eastern markets.

The hard labor and considerable expense connected with the settlement of a new area, and with bringing the prairie into cultivation, placed the pioneers in desperate need of a cash crop. Wheat met this need admirably. As a rule the pioneers had limited financial resources. Many of them had sold a farm or small business to obtain the money to cover their traveling expenses to the West, to pay or partially pay for their new land, and to buy the tools and other equipment needed to break and

cultivate it. Once in Minnesota, the cost of opening a farm was estimated as follows:[1]

The price of their land	$200.00
The price of team and wagon	150.00
The price of two cows	40.00
For rebuilding house	100.00
Breaking twenty acres	60.00
One steel plow, for crossing	14.00
One harrow	6.00
Axes, shovels, spade, forks, scythes, etc	25.00
House furniture, and provisions for family, which must be bought till they can raise them	200.00
	$795.00

That amount now seems a small price to pay for a farm, but it was more than many men could get together at that time. In order to secure the money necessary to purchase land or to develop their property some men had to work for a time as hired men or spend the winter in the pineries working for the lumber companies.

During the first few years of settlement, the chief interest and business of the settler was to plow a part of his farm, though it was not possible or desirable for a man to plow all of it. In general, no more was plowed than a man could cultivate himself, which was about 40 acres.[2] As the sod on the prairie was compact and deep, it was not easy to break. Such strenuous work required a big 16-inch breaking plow and from four to six oxen or horses. As few of the settlers had more than one team, they commonly put their teams together and plowed each man's land in turn.[3] In the wooded areas, plowing was possible only after the trees had been cleared off, and even then the roots of the trees made plowing difficult. For a number of years it was necessary for a farmer to raise most of the food for his family. Corn, potatoes, rutabagas, and turnips did well in newly turned sod, in spite of the fact that in most instances farmers were too busy to give them much attention.[4]

During the rush of settlers in 1855-1856, when foodstuffs had to be imported into Minnesota, a farmer who had a surplus of these crops or of pork or other meat

[1] 1st Annual Report of Commissioner of Statistics for Minnesota (Hartford, 1860), pp. 30, 87.
[2] Ibid., p. 87.
[3] Mills, J. C., in History of Fillmore County (Chicago, 1912), p. 503.
[4] Ibid., p. 505.

undoubtedly found an active market for it. By the second or third year, wheat was planted and it did well. It was ground into flour at small waterpower grist mills which shortly after settlement developed at many points in the valleys. In case a local mill was not available, the wheat had to be hauled many miles to a mill, but this involved much time and labor, and often one-third or more of the flour was taken for grinding. A team of horses or oxen, a few chickens, a hog or two, and a cow represented the stock on an average farm. Some attempts were made to raise sheep, but for a number of years so many of them were killed by wolves that they did not prove profitable.[5]

In addition to the work connected with growing a crop, it must be remembered that the settlers had to obtain fuel for the long, cold winter; cut wild hay on the prairies or the valley meadows for the stock; build homes, barns, fences, and churches; open roads, and bring supplies from market, so that, altogether, the first years of settlement in southeastern Minnesota were characterized by strenuous toil and considerable hardship, and were fraught with anxiety as to whether or not prosperity eventually would reward their efforts. In view of these conditions, it is easy to understand that, when it was demonstrated that large crops of wheat could be produced from the virgin soils and that wheat sold for cash, wheat growing came to be almost the sole economic interest of the farmers.

Although by 1859 it was evident that wheat farming had become the principal money crop in the area, it was not until the decade from 1870 to 1880 that bonanza wheat farming reached its maximum development (Fig. 1). This was due to the fact that a number of problems affecting the industry had to be solved before maximum acreage and production were attained. Of these the discovery that spring wheat was better adapted to local conditions than winter wheat, the introduction of milling processes suited to hard wheat, the improvement of transportation on the river, the establishment of warehouses and eleva-

[5] History of Winona County (Chicago, 1883), p. 263.

tors to handle the grain, and the building of railroads were the more important.

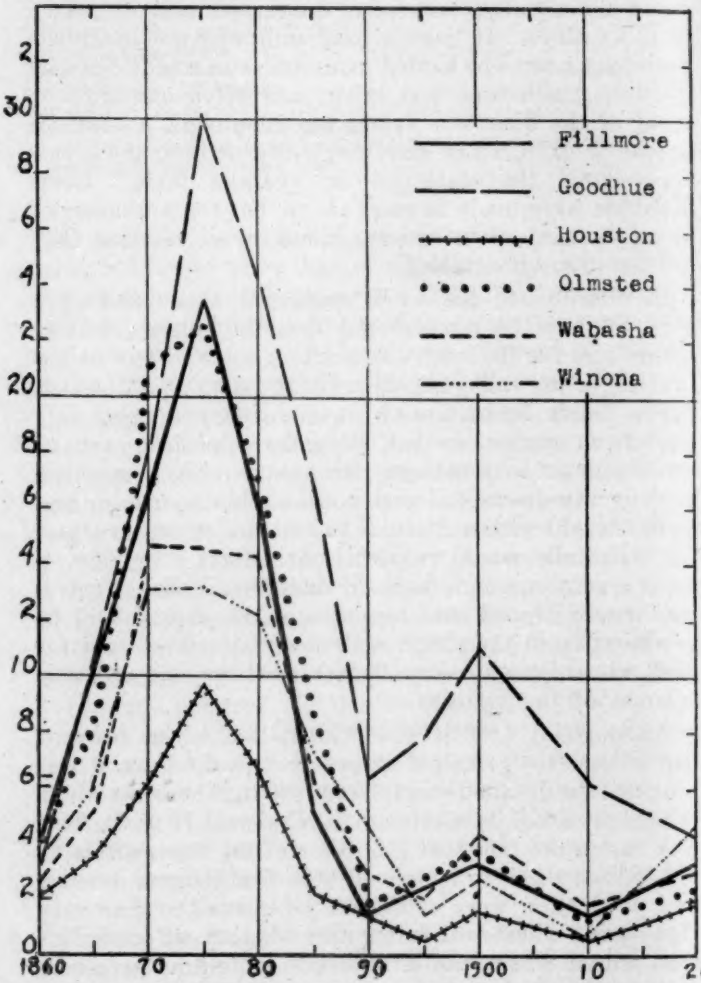


Fig. 1. Production of wheat in units of 10,000 bushels in the six counties of Southeastern Minnesota by five year periods from 1860 to 1920 inclusive. Data for the even years is from the United States Census, for the odd years from the annual reports of the Commissioner of Statistics for Minnesota. Statistics for 1905 and 1915 are not available. The graph shows that in these counties the period of bonanza wheat farming extended approximately from 1865 to 1885.

Fig. 2. Southeastern Minnesota. The major portion of the wheat produced in Southeastern Minnesota has been grown on the broad, nearly-level, loess-covered, upland into which the deep, steep-sided valleys of Root, Whitewater, Zumbro and Cannon rivers are cut.

Wheat culture in the area began in 1853 when a crop of winter wheat was raised on the alluvial terraces in Rollingstone Valley in Winona County,[6] and probably also in some of the terraces in Houston and Fillmore counties. Such alluvial terraces rise in many places above the flood plains of the streams, and comprise the principal areas farmed in the valleys. Wheat raising spread to the upland somewhat slowly because the valley

[6] Ibid., p. 262.

walls of the Mississippi are so steep that the upland farms were not readily accessible, until roads were built to them. Southeastern Minnesota is a region of nearly horizontally bedded limestone, sandstone, and shales, dissected to topographic early maturity by the Mississippi River and a number of its tributaries. It consists of nearly level upland tracts, the surfaces of which are about 1,150 feet above sea level, and of the valley floors of the Mississippi River and its tributaries, which lie from 350 to 400 feet below them. The upland corresponds in surface to most of southeastern Minnesota, and it constitutes the larger part of this area. The Root, Whitewater, Zumbro, and Canyon rivers flow across the area from west to east (Fig. 2). The deep valleys of these streams divide the upland into wide, flat-topped ridges which, like the rivers, extend from west to east across the area. The broad summits of these ridge-like remnants of the upland are fine farm lands, but their margins are not because they are too greatly dissected by the head ravines of the streams. The following table shows that

SHIPMENTS OF FARM PRODUCE FOR RIVER POINTS IN SOUTHEASTERN MINNESOTA IN 1859[1]

(Bushels)

Ports	Wheat	Oats	Corn	Barley	Potatoes
Red Wing	30,000*	.....	.....	.....	.....
Lake City	18,000	.....	.....	.....	3,400
Wabasha	4,800	10,000	.....	.....	2,000
Reed's Landing	3,000	5,000	.....	.....	1,000
Minneiska	12,000*	.....	.....	.....	.....
Mt. Vernon	3,000*	.....	.....	.....	.....
Winona	177,000	35,000	.....	9,000	6,000
La Crescent	15,000	1,000	2,000	.....	2,000
Hokah	3,000	.....	.....	.....	.....
Brownsville	32,000	4,000	.....	1,000	.....

in 1859 wheat had already attained first place among the crops.

The large shipments of wheat from Winona were due to the fact that Winona County was settled early, and that a larger tract of undissected upland suited to farming is tributary to Winona by wagon haul than to any other point along the river. A road was built at an early

[1] Robinson, E. V.: Early Economic Conditions and the Development of Agriculture in Minnesota (Minneapolis, 1915), p. 45, as corrected from 1st Annual Report of Commissioner of Statistics for Minnesota (Hartford, 1860), p. 155.

* All grains, but principally wheat.

date from Wabasha Prairie, a river terrace on which the city of Winona is located, to the upland along each of the several small valleys which focus on the terrace.

During the pioneer years some attempts were made to grow winter wheat on the upland prairies. Of those in Olmsted County local reports state that winter wheat was a success only once in three years[8], and this experience was found to hold on other prairies. In most years the wheat was killed during the winter because the prairies were so broad, open, and windswept that the snow was blown off, leaving the wheat exposed to the alternate freezing and thawing occasioned by diurnal and cyclonic temperature changes. In some years the fall of snow was too light or came too late in the season to protect the wheat[9]. In other years a warm spell melted the snow and covered the fields with water, which if it became ice killed the wheat.

In the valleys and timbered tracts, snow drifts much less than on the prairies, so that winter wheat was grown successfully. In 1859, the commissioner of statistics addressed specific inquiries to the different counties, asking for reports on the success of winter wheat. The replies showed that it was a failure in the counties which were mainly prairie, but was a success in those which included large areas of bluff lands or timber[10]. Until the improved methods of milling were introduced, the winter wheat crop in the valleys and wooded tracts in the southeastern part of the state was important. Good flour was made from it in the small water-power mills located near rapids or falls in the streams. Some of these mills gained a considerable local reputation for their flour. A few of them have been in business for more than fifty years, grinding the small amount of wheat annually produced in the communities tributary to them.

The pioneers shortly discovered that spring wheat is adapted admirably to the conditions on the upland prairies. The crop seldom is damaged by frost[11], as the growing season, varying from 140 to 150 days, is ade-

[8] First Annual Report of Commissioner of Statistics (Hartford, 1860).
[9] Ibid., p. 94.
[10] Ibid., p. 94.
[11] Purcell, V. G.: Climatic Conditions of Minnesota, Minnesota Geological Survey, Bull. No. 12, pp. 19-21.

quately long for this crop. Wheat is sown in the latter part of April or early in May, and grows rapidly through May, June, and the early part of July, which are the months of greatest rainfall. It ripens and is harvested in August, in which month hot, dry spells of weather are characteristic. The farmers have discovered that if sowing is delayed by a late spring or by other causes, the crop may come into "the milk" during a late summer dry spell and be injured. Judging by a comparison of crop yields with the weather records spring wheat has done well in most seasons since its culture began in this area. However, the decrease in yield per acre after 1875 was attributed incorrectly, by some writers, to vagaries of the weather[12].

By 1860, in the river counties of Minnesota, houses and barns were built and other improvements made, so that the farmers had time to cultivate more of their farms. In that year fifty per cent of the improved land in the counties facing on the Mississippi, and thirty per cent in the counties remote from the river but still within hauling distance, were planted to wheat[13]. As it became evident that wheat was the most profitable crop, more and more land was devoted to it. A man's income increased with the size of his crop, and consequently large acreages were planted.

The establishment of the one-crop system in this area was favored by the large yields of wheat produced from the fertile soils. The average yield per acre for the state as a whole was 22.05 bushels in 1860[14]. With the exception of Houston County, all of the counties in this area had an average yield per acre greater than that for the state. In some townships in these counties the average yield per acre was exceptional. In New Hartford township in Winona County it was 33.2 bushels, in Douglas township in Fillmore County, 27.7 bushels, and in Goodhue township in Goodhue County, 27 bushels[15]. In the next decade the average yield per acre varied from time to time, according to the season, but in 1875, twenty

[12] History of Winona County (Chicago, 1883), p. 99.
[13] Second Annual Report of Commissioner of Statistics, pp. 128, 129, 131.
[14] Second Annual Report of Commissioner of Statistics of Minnesota (St. Paul, 1861), p. 57.
[15] Ibid., p. 58.

years after settlement, the average yield per acre was 21.08 bushels in Goodhue, 18.02 in Fillmore, 19.64 in Olmsted, 18.06 in Wabasha, 17.55 in Winona, and 17.34 in Houston County[16]. After 1880, however, the average yield rapidly decreased. While statistics are not available to show which type of soil maintained high yields for the longest time, there is little doubt that the yield on the loess soils was satisfactory for some years after other soils were exhausted.

The scarcity of labor which prevailed in these early years somewhat retarded the increase of wheat acreages. Land was so cheap that nearly every man owned or hoped to own a farm rather than to work for some one else. Other parts of the West were developing at the same time, and the immigration of laborers into any one area seldom equalled the demand for them. As a result of this labor shortage and the profits in wheat farming, labor-saving farm machinery was adopted rapidly. Sulky plows, disk harrows, seeders, reapers, binders, threshing machines, fanning mills and other machines found a ready sale when they were put on the market. In southeastern Minnesota the use of farm machinery was favored by the nearly level surface and the fine textured, well-drained loess and weathered drift soils of the upland prairies. Moreover the shortage of labor during harvest, when it was most acute, was solved, in part at least, by the importation of gangs of men who had previously worked in the wheat fields in states to the south. The extension of the wheat growing area northward simply prolonged the working period of these men and brought them near the Minnesota and Wisconsin forests where many of them were employed in the winter.

The use of this machinery and the adoption of this harvesting practice so increased the acreage of wheat on many farms that the profits earned enabled many men to increase the size of their farms. Consequently holdings of from 300 to 1,000 or more acres were not uncommon. The profits were so great in many instances that

[16] 8th Annual Report of Commissioner of Statistics for Minnesota (St. Paul, 1877), p. 36.

nearly every man in a community tried to own a piece of land. Storekeepers, shopkeepers, mechanics, and professional men bought farms which they partially worked themselves or rented "on shares" to farmers[17]. Quick returns led to speculation. Threshing outfits costing about $800 in some instances paid for themselves in two years[18]. Farmers ran store bills and bought machinery on time, and in many instances the returns from their crops more than warranted the outlay. There was small incentive for the farmers to use either their land or machinery carefully. Straw stacks were burned as the easiest way to dispose of them. Binders costing more than $200, and other machines and tools, in many instances were left in the field until wanted in the next season. As a result they rapidly depreciated in utility and value[19]. The prairie soils yielded so readily to the plow, wheat was relatively such an easy crop to grow, and yields were for the most part so satisfactory, that it is no wonder that farmers became a bit careless about expenses.

The acreage and production of wheat in southeastern Minnesota and elsewhere in the Spring Wheat Belt increased rapidly after certain developments in the marketing phase of the industry occurred. A notable one was the introduction of the "middlings-purifier" and other milling improvements which made it possible to produce a high-grade flour from the hard spring wheat[20]. The improvement of transportation to eastern markets was even more important. This was accomplished by (1) an increase of the number of steamboats on the river, (2) the introduction of river barges especially designed for carrying wheat, (3) the erection of warehouses and elevators along the railroads and at the steamboat landings, (4) the establishment of rail connection between the Mississippi and the Great Lakes, and (5) the construction of railroads westward from the Mississippi. The importance of these developments is reflected in the fact that in 1865, sixty-five per cent of the land under

[17] Schatzel, G. W.: Among the Wheat Fields of Minnesota, Harper's Magazine, XXXVI, January, 1868, p. 197.
[18] Ibid.
[19] Ibid., p. 200.
[20] Robinson, op. cit., p. 77.

cultivation in Olmsted County was planted in wheat[21], and that in 1870, Fillmore, Goodhue, Wabasha, and Winona Counties, each produced more than 1,300,000 bushels of wheat, and Olmsted County more than 2,000,000 bushels (Fig. 1). The relative importance of the southeastern counties is indicated by the fact that with one exception the counties mentioned were the only ones in the state to raise more than 1,000,000 bushels[22].

Climax of wheat raising. Bonanza farming in the southeastern counties culminated in the five years from 1875 to 1880. The largest acreage in the state as a whole occurred in 1878, when wheat was grown on 68.98 per cent of all cultivated land[23]. In the southeastern counties the largest crop was produced in 1875, when these counties produced 38 per cent of the state's crop. The production and distribution of the crop in that year by counties and townships clearly reflects the natural invironment. In that year, Wabasha and Winona counties each produced more than 1,000,000 bushels of wheat, Olmsted and Fillmore counties more than 2,000,000 bushels, and Goodhue County more than 3,000,000 bushels[24] (Fig. 1). The three counties last named owe their large production to (1) their large size, (2) their nearly level surface, being much less dissected than Houston, Winona and Wabasha counties, and (3) their fertile loess and glacial soils.

In Goodhue County wheat was raised on 30 per cent of its area and occupied 81 per cent of its cultivated land. Such a production led early writers to describe Minnesota as one continuous wheat field[25] and to claim that Red Wing was the "leading primary wheat market in the world[26]". Vasa, Belle Creek, Goodhue, Wanamingo and Zumbrota townships each produced more than 190,000 bushels of wheat in the year in question. All of them have a nearly level surface, a loess soil, and little waste land. In the northern part of the county the pro-

[21] Annual Report of the State Auditor, Session of 1867, Minnesota Ex. Docs. for 1866, p. 61.
[22] 9th Census of the United States; Robinson, op. cit., pp. 260, 261.
[23] Robinson, op. cit., p. 79.
[24] 8th Annual Report of Commissioner of Statistics (St. Paul, 1877), p. 36.
[25] Geol. and Nat. Hist. Surv. of Minn., Vol. I, p. 337.
[26] Hancock, R. W.: Past and Present in Goodhue County, (Red Wing, 1893), p. 187.

duction was small, reflecting the dissected surface and less productive soils of that section. Likewise the acreage and production of wheat was relatively small in northwestern Olmsted County where the surface is dissected by the South Branch of Zumbro River, the drift is thin, loess is absent and the soil derived from the sandstone or limestone formations is poor[27]. The two leading townships in wheat production in the state in that year were Farmington township in the northeastern part of Olmsted County and Elgin township in Wabasha County, which joins it on the east, each of which produced more than 200,000 bushels. These townships cover a broad and nearly level stretch of prairie with a deep and fertile loess soil[28].

In Fillmore County the townships in which the yield was less than 100,000 bushels were in the dissected lands contiguous to Root River and its tributaries. In Winona and Houston counties the townships along the bluff lands of the Mississippi and Root valleys, and the upland ridges produced less than 100,000 bushels. The townships of maximum production were those occupying Wilmington Prairie in Houston County and Lewiston Prairie in Winona County[29]. In all of these counties, the townships in which more than 100,000 bushels of wheat were raised are on the uplands. In general, the greatest yields came from townships with a minimum of dissection, and from those which have loess over much of their surface.

After 1880 the acreage and production of wheat in southeastern Minnesota declined rapidly and the acreage and production of oats, corn, and barley, and the number of livestock increased. Although this change in the farm system was due to several conditions, the most important were the low price for wheat which prevailed after 1880 and a gradual decrease in the yield per acre.[30] The average yield per acre for the six counties in this area in 1875 was 18.6 bushels; by 1880 it had dropped to 11.5 bushels. Moreover, weeds became such a menace

[27] Geol. and Nat. Hist. Surv. of Minn., Vol. I, pp. 337-338.
[28] 8th Annual Report of Commissioner of Statistics, pp. 29-34.
[29] Ibid.
[30] Robinson, op. cit., p.

on account of consecutive wheat crops on the same land, that it was necessary to plant other crops in order to get rid of them.[31] The locust plague, which partially destroyed the crop in the central and western parts of Minnesota from 1872 to 1877, did not affect the southeastern counties in any large way.[32] On the other hand, the chinch-bug appeared first in the southeast, and in 1877 destroyed two-fifths of the crop in Houston County.[33] The ravages of this insect were sufficient to make profits from the wheat crop uncertain.

By the middle of the decade, from 1880 to 1890, railroad mileage was extended so that most farms were within 10 miles, or nearer, of a station, and it was possible to market other farm products profitably. During the same decade, breweries began business in LaCrosse, Winona, Wabasha, and Red Wing, and a local market for barley was created. In addition, the losses incurred in wheat farming had led many farmers to mortgage their farms, so that progressive farmers realized that a change must take place. The Commissioner of Statistics and other state officials, the scientists from the State Agricultural College, the State Dairy Commissioner, the State Dairymen's Association and other agricultural societies combined with the state press in a protest against the old method of farming. Gradually the change to a more diversified crop system took place.

[31] Bull, C. P.: Barley Investigations, University of Minnesota Agricultural Experiment Station, Bulletin 148, p. 7.

[32] Statistics of Minnesota, 1873, p. 192; 1874, pp. 7-9; 1875, pp. 19-22; 1876, pp. 49, 80, 88; 1877, pp. 17, 19; 1878, p. 9. Fifth Report of Agricultural Experiment Station, pp. 96-97.

[33] Statistics of Minnesota, 1877, pp. 18, 94.

THE COTTON INDUSTRY OF SOUTHERN ILLINOIS

FRANK H. COLYER, STATE NORMAL UNIVERSITY, CARBONDALE

COTTON GROWING AN EARLY INDUSTRY IN ILLINOIS

While the exact date of the first cotton grown in Illinois is perhaps unknown, yet it could not have been many years after the first permanent English settlements. As proof of this, Governor John Reynolds, in speaking of the early cotton industry in Illinois says: "The first gin was established in 1813."[1] This statement of Reynolds is in complete accord with that of J. M. Peck, who wrote his Gazetteer of Illinois in 1837. In this book Peck says: "Cotton, for many years, has been successfully cultivated in this state (Illinois) for domestic use, and this branch of business admits of enlargement; and invites the attention of eastern manufacturers with small capital."[2] Peck further states: "A few factories for spinning cotton yarn have been put into operation in several counties on a small scale of from one hundred to two hundred spindles each."[3]

H. L. Ellsworth in his book, "Illinois In 1837," makes this significant statement concerning early cotton manufactures in Illinois: "Coarse clothing from cotton is manufactured in the southern portion of the state, where the article is raised in small quantities. Woolen cloth, and jeans, a mixture of wool and cotton, is made for ordinary wear, as is cloth from flax."[4] From these early writers it is clear that cotton was not merely grown in Illinois at a very early date, but cotton yarn and cotton cloth were made for commercial purposes in addition to that made and consumed in the homes of the early settlers.

It is also quite probable that available statistics do not show the entire amount of cotton raised, for the reports show the amount of lint by bales. Baled cotton was for

[1] Reynolds, John: Pioneer History of Illinois. Page 398.
[2] Peck, J. M.: Gazetteer of Illinois. Page 22.
[3] Peck, J. M.: Gazetteer of Illinois. Page 32.
[4] Ellsworth, H. L.: Illinois in 1837. Page 59.

"export" and did not represent that used in the home, for such cotton was evidently not baled.

AMOUNT OF BALED LINT PRODUCED FROM 1839 TO 1880

In 1839	amount	of	lint	produced	in	Illinois	was	402	bales.
" 1859	"	"	"	"	"	"	"	1186	"
" 1860	"	"	"	"	"	"	"	1482	"
" 1865	"	"	"	"	"	"	"	7609	"
" 1870	"	"	"	"	"	"	"	465	"
" 1875	"	"	"	"	"	"	"	13	"
" 1876	"	"	"	"	"	"	"	about 1	"
" 1877	"	"	"	"	"	"	"	118	"
" 1878	"	"	"	"	"	"	"	6	"
" 1879	"	"	"	"	"	"	"	18	"
" 1880	"	"	"	"	"	"	"	95	"

While available statistics do not show the production for each year, yet they do show that cotton was probably continuously grown from the period of the early English settlements of Illinois to at least 1880. It is quite probable that cotton continued to be grown on a small scale till about 1910 or even later. The writer distinctly remembers seeing a field of cotton between Mound and Mound City about 1910.

COTTON INDUSTRY DURING CIVIL WAR

In 1865 cotton culture in Illinois reached its high water mark for the 19th century. This was due almost wholly to the changed economic conditions caused by the war itself. President Lincoln's proclamation closing the southern ports to all foreign trade, together with lack of labor on many southern plantations near the close of the

COTTON PRODUCTION IN 13 ILLINOIS COUNTIES IN 1865.

Counties	No. of acres planted	Yield per acre	No. of bales of lint	Price per lb. in seed	Amount realized
Jackson	3,280	800 lbs.	1,876	10¢	$378,065
Union	2,700	800 "	1,458	10¢	$199,757
Williamson	1,678	800 "	1,000	10¢	$141,750
Johnson	1,000	900 "	800	9½¢	$136,800
Massac	728	800 "	370	9½¢	$ 55,361
Perry	661	800 "	639	9¢	$ 56,563
Franklin	625	800 "	356	9½¢	$ 47,500
Jefferson	435	800 "	240	9¢	$ 27,920
Pope	350	800 "	190	9¢	$ 22,680
Alexander	310	800 "	250	9¢	$ 18,700
Gallatin	300	800 "	200	9¢	$ 21,600
Pulaski	123	1100 "	200	10½¢	$ 13,500
Hardin	45	800 "	30	8¢	$ 4,200
Totals	12,835		7,609		$1,125,396

war, caused a very serious shortage of raw cotton both in America and western Europe. Thus the price of cotton was high and many southern Illinois farmers found cotton the most profitable crop they could raise.

These statistics show some rather remarkable things. In the first place, the largest producing counties in 1865 were not the extreme southern counties of Alexander, Pulaski, Massac, and Pope, but Jackson, Union, Williamson and Johnson counties, somewhat farther north. Jackson county alone produced more than twice as much as the five southernmost counties combined. In the second place most of the cotton was not produced in the more fertile bottom lands of the Mississippi and Ohio Rivers, but on the warmer south and east slopes of the hill lands of Jackson, Union, Williamson, and Johnson counties. Even the hill county of Massac produced more than twice as much cotton as the two counties of Pulaski and Alexander with their much larger proportion of river bottom land. The explanation of this is that the river bottom lands in 1865 were still largely in timber, poorly drained, and not well protected from floods, while the hill lands still retained much of their virgin fertility of soil, were warmer, and much better drained. Cotton needs warm and well drained lands quite as much as lands of high fertility.

Owing to the fact that the Illinois Central railroad was the only road having a direct outlet to the north and thence east to New York City, nearly all the cotton was marketed in towns along the Illinois Central railroad. Of all these towns Carbondale was the most accessible to the chief cotton producing counties and as a consequence became the chief cotton market in Illinois. In 1865 there were 11 cotton gins in and near Carbondale. Carbondale was the shipping point for most of the cotton of Jackson, Williamson, Saline, Gallatin, northern Hardin, Pope, and Johnson counties.

The importance of Carbondale as a cotton market can be gained also from this statement of Newsome, who says: "At one time there were about a dozen cotton gins

[8] Pearcy, A. J.: Transactions of Ill. State Agr. Society. Vol. 6, 1865-6, Page 66.

in town (Carbondale), so in the autumn, the place had very much the appearance of a southern town, for the cotton was everywhere, and the bales were piled upon the depot platform ready for shipment. The price was high, money was plenty, and business lively[6].'' It is quite probable that more than one-half of the 1,125,396 dollars worth of cotton shipped from Illinois in 1865 was shipped from Carbondale. For a few years after the Civil War cotton continued to be one of the leading money crops in several southern Illinois counties; but as the South gradually recovered from the war, cotton growing increased, prices grew less and Illinois being unable to compete with the southern cotton grower, the industry gradually declined and finally ceased entirely about 1910 or soon thereafter.

REVIVAL OF COTTON GROWING IN 1923 AND 1924

Perhaps at no time in the history of Illinois has more been said and done to revive cotton growing in this state than has been the case in the last two years. Bankers, farm advisers, lawyers, merchants, farmers and others have been persistently advocating the possibilities of cotton production, particularly in the counties of Pulaski, Alexander, Union, Massac, and Johnson. Bankers and lawyers have visited the southern cotton growing states to study how best to start the industry. Experienced cotton men from the South, and the national government have been brought to these counties where large and enthusiastic meetings with prospective growers have been held. At these meetings such questions as these have been discussed: the time to plant cotton, the type of soils, the best kinds of cotton for southern Illinois, manner of preparing seed bed and of cultivating cotton, the amount one man can plant, cultivate and pick, and finally how and when best to pick and how to sell the crop.

CHIEF CAUSES THAT HAVE PRODUCED THIS REVIVAL

Chief of the causes that have contributed to this renewed interest in cotton growing is the destruction due

[6] Newsome, E. "Historical Sketches of Jackson Co. Ill.," Page 124.

to the ravages of the boll weevil in the southern cotton growing states. Second, there is a general belief among experienced cotton growers that the boll weevil will not be a serious menace to cotton growing in southern Illinois, due to the colder winters of this section of the country.

The third reason for this revival in cotton growing is the development, by careful seed selection, of earlier maturing varieties of cotton that can mature a paying crop in these more northern regions with their shorter growing seasons. Such early varieties as trice, acula, delfos and express can mature an early crop of high grade cotton in latitudes of southern Illinois.

The fourth reason is that cotton has been successfully grown in southern Illinois for a great number of years. Added to this is the influence of the largely increased growing of cotton just across the state border, in southeastern Missouri. This rather large scale production in southeastern Missouri has been so pronounced that it has attracted the attention of business men and farm advisers in adjoining sections of southern Illinois.

There are other, but perhaps more temporary, causes for this recent activity in cotton planting. These last may even be the greater stimuli to many farmers who will plant cotton this season. The greatest of these stimuli is the present high price of cotton. Very closely connected with this is the fact that farmers generally have made but little out of wheat, corn, alfalfa, and live stock in the last few years and are as a consequence ready to listen to any suggestion of some farm product that promises better money returns than the present day staple crops. Experience alone must in the future determine whether these stimulating causes have sufficient merit to justify present expectations. They certainly seem to have. While there is still some uncertainty as to the cotton acreage for 1924, yet conservative estimates place the amount somewhere between 15,000 and 18,000 acres. It may go to 20,000. These estimates are based on amounts of cotton seed already purchased through farm advisers in the various cotton producing counties.

The accompanying table shows approximately the chief cotton planting counties for 1924 and the amount to be planted in each.

Pulaski and Alexander, together, estimated from 10,000 to 12,000 acres.

Union	County	estimated	acreage	about	2,500	to 3,000	acres.
Massac	"	"	"	"	750	" 1,000	"
Johnson	"	"	"	"	1,000	" 2,000	"
Jackson	"	"	"	"	250	" 300	"

For Williamson, Pope, Saline, and perhaps other counties, no definite figures are available, but each will plant a small amount. Pulaski probably will have the largest acreage, which will be closely followed by Alexander county.

In contrast to the cotton growing counties of the Civil War period, it will be noticed that the extreme southern counties, with their larger share of bottom lands, will lead; and the more hilly lands to the north will take a decidedly lower rank. The explanation of this contrast with 1865 is that the river bottom lands are much more fertile, they are now much better drained than formerly, and the construction of levees in recent years gives greater protection from floods.

In the larger producing counties of Pulaski, Alexander and Union the labor in the cotton fields will be done chiefly by negroes from the South. These are experienced cotton raisers who have left the South because of the ravages of the boll weevil and are as a rule very poor. The land owners lease the land, furnish food, implements, seed, teams, and get one half of the crop. In the other counties the labor will be largely performed by native white labor on their own farms.

This seasons trial of cotton growing will be watched eagerly, particularly by southern Illinois farmers, and upon its success the future of cotton growing in this section will largely depend.

The chief hope of southern Illinois becoming again a part of the cotton growing region rests largely upon the oft repeated statements of experienced cotton growers from the South who declare to prospective Illinois growers, "You are on the same footing as we of the Gulf States because we must plant early maturing varieties to get the crop far enough advanced before the boll wee-

vil becomes sufficiently numerous to effect the crop seriously." In other words, the growing season for these early maturing varieties is about the same in southern Illinois as in the Gulf States.

THE CORRELATION OF THE MAQUOKETA AND RICHMOND ROCKS OF IOWA AND ILLINOIS

T. E. Savage, University of Illinois

The rocks of Richmond age in southeastern Iowa have been called the Maquoketa formation, or Maquoketa shale, from the Little Maquoketa River in Dubuque County, Iowa, along which they are well exposed. Corresponding strata also outcrop in the northwest part of Illinois.

The lower strata of Richmond age in southern and eastern Illinois have been correlated with the Fernvale[1] limestone. They are exposed in a number of places along the Mississippi River in the southwest part of the State, for example, near Thebes in Alexander County, and near Val Meyer in Monroe County. Outcrops of this limestone also occur in adjacent portions of Missouri, as at Cape Girardeau. Strata of corresponding age also outcrop in Will and Kendall counties, in the northeast part of the State. One of the localities in which they furnish an unusual number of bryozoa and other fossils in an excellent state of preservation is in the banks of Kankakee River at Wilmington, Illinois, where the exposed section is as follows:

SECTION OF RICHMOND STRATA IN THE VICINITY OF WILMINGTON

2. Shale, bluish-gray, with few fossils	35 ft.
1. Limestone, shaly to subcrystalline, in irregular layers that contain numerous fossils	12 ft.

The Richmond sediments were deposited on an eroded surface so that in some places in northeastern Illinois a thickness of 40 or 50 feet or more of shale of Richmond age underlies the limestone member exposed at Wilmington. This limestone is also in places thicker than in the Wilmington section. There are no fossils in the shale beneath the limestone by which its age can be determined. However, as the two members do not appear to be separated by an unconformity, the shale probably represents the initial deposits of the formation to which the limestone belongs.

[1] Savage, T. E., The faunal succession and the correlation of the pre-Devonian formations of southern Illinois. Bull. No. 16, Ill. State Geol. Survey, pp. 315-318, 1910.

The more calcareous layers in the lower part of the section at Wilmington furnished the species of fossils listed below. In this list and those that follow the relative abundance of each species is indicated by the letters r—rare, c—common and a—abundant, placed after the name. If the species occurs in the Richmond strata of Indiana, the particular formation of the Richmond in which it is found in Indiana is indicated by the letters A—Arnheim; W—Waynesville; L—Liberty; Wh—Whitewater; and E—Elkhorn, following the name in the lists.

LIST OF FOSSILS FROM THE LOWER PART OF RICHMOND STRATA AT WILMINGTON

Anolotichia ponderosa Ulr. (a)
Anaphragma mirabile U. & B. (c)
Anaphragma mirabile n. var (r)
Arthroclema angulare Ulr. (c)
Atactoporella cf. schucherti Ulrich (r) W. Wh.
Batostoma prosseri C. & G. (c) W. L.
Batostoma variabile Ulr. (r) W. E.
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (r) W. L. Wh.
Ceramoporella granulosa Ulr. (r) A. W.
Ceramoporella ohioensis (Nich) (r) Richmond
Ceramoporella whitei (James) (r) A. W.
Constellaria polystomella (Nich) (c) W. L.
Constellaria punctata (Whitfield) (c)
Crepipora hemispherica Ulrich (r)
Crepipora simulans Ulr. (r)
Cyclotrypa n. sp. (r)
Cyphotrypa stidhami (Ulr.) (c) Wh.
Cyphotrypa wilmingtonensis U. & B. (r)
Dicranopora emacerata (Nich.) (r) Richmond
Eridotrypa simulatrix (Ulr.) (c) W.
Favositella epidermata (Uri.) (r-c)
Hallopora subnodosa (Ulrich) (r) Richmond
Helopora imbricata Ulr. (c)
Hemiphragma imperfectum (Ulr.) (aa)
Heterotrypa affinis (Ulr.) (c)
Heterotrypa prolifica Ulr. (r) W.
Heterotrypa singularis Ulr. (r) W.
Heterotrypa subramosa (Ulrich) (r) W.
Homotrypa cf. communis Bassler (r) W. L.
Homotrypa flabellaris Ulrich (r) W. L. Wh.
Homotrypa gelasinosa Ulr. (r)
Homotrypa cf. similis Foord (r)
Homotrypella rustica var. n. (c)
Mesotrypa orbiculata C. & G. (r) A.
Nicholsonella n. sp. (c)
Nicholsonella n. sp. (r-c)
Nicholsonella cumulata Ulr. (r)
Pachydictya elegans Ulr. (r-c)
Pachydictya fenestelliformis (Nich.) (a) W. L.
Pachydictya fenestelliformis corticula Ulrich (r)
Pachydictya firma Ulr. (a)

Pachydictya gigantea Ulr. (a)
Pachydictya hexagonalis Ulr. (r)
Pachydictya magnopora Ulr. (c)
Pachydictya splendens Ulr. (r)
Peronopora decipiens Rom. (a) A. E.
Phenopora wilmingtonensis Ulrich (r)
Phenopora wilmingtonesis var. (r)
Protocrisina exigua Ulrich (r)
Ptilotrypa obliquata Ulrich (c)
Rhombotrypa crassimuralis (Ulrich) (r)
Rhombotrypa quadrata (Rominger) (c) W. L. Wh.
Rhombotrypa subquadrata (Ulrich) (r) W. L.
Stigmatella interporosa U. & B. (r) W.
Stigmatella sp. (r)
Stomatopora arachnoidea (Hall) (c)
Dalmanella tersa Sardeson (r)
Dalmenella testudinaria (Dalman) (c)
Dinorthis proavita (Winchell and Schuchert) (c)
Dinorthis subquadrata (Hall) (c) L. Wh.
Hebertella insculpta (Hall) (c) W
Hebertella occidentalis (Hall) (c) Richmond
Lingulasma schucherti Ulrich (r)
Parastrophia divergens Hall and Clarke (r)
Platystrophia cumingsi McE. (c) W.
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis kankakensis (McChesney) (c)
Rafinesquina alternata (Emmons) (c) Richmond
Rafinesquina kingi (Whitfield) (r)
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema periamellosum (Whitfield) (c)
Strophomena neglecta (James) (c) W
Strophomena nutans (Meek) (r) W
Strophomena planumbona (Hall) (c) W. L.
Strophomena planodorsata Winchell and Schubert (c)
Strophomena wisconsinensis (Whitfield) (c)
Ambonychia sp (r)
Hormotoma sp (r)
Orthoceras sp
Endoceras proteiforme Hall (r)
Cyrtoceras sp (r)

* Note: The bryozoa in this and the following lists were identified by Professors E. R. Cumings and J. J. Galloway.

Of the fossils in the foregoing list that are present also in the Richmond strata of Indiana, 12 species occur there in the Waynesville formation and do not appear in younger Richmond strata. Eleven other species occur in Indiana in both the Waynesville and the Liberty formations. Twelve of the species range from the Waynesville to the Whitewater formations. None of the species are restricted to the Liberty formation in Indiana, and only one of the number is found in Indiana only in the Whitewater formation. Such species as Dinorthis subquadrata that is not present in Indiana in the Waynesville, but occurs there in both the Liberty and White-

water formations, and Cyphotrypa stidhami that occurs in Indiana only in the Whitewater formation, are present in Illinois in the same layers that contain Hebertella insculpta and other species that in Indiana are restricted to the Waynesville formation. Such species do not indicate that the rock from which they come are Liberty or Whitewater in age, but they show that some of the species have a different vertical range in Illinois from what they do in Indiana. The range of the species indicated in the above list is conclusive evidence that the Fernvale limestone at Wilmington, Illinois, corresponds in age to that of the Waynesville more closely than to any other formation of the Indiana Richmond, and it is considered as Waynesville in age.

Another exposure of Richmond limestone occurs near the mouth of Rock Run, about six miles west of Joliet, where the section is as follows:

	Feet
Shale, bluish to yellowish, slightly sandy; few or no fossils	18
Concealed	4
Limestone, gray, subcrystalline, in rough layers 4 to 5 inches thick, alternating with bands of bluish-gray, calcareous shale. Fossils are numerous in the limestone layers	4
Limestone, gray, subcrystalline, in uneven layers 3 to 8 inches thick, containing many fossils	7

The fossils collected from the limestone layers at the Rock Run locality include the following species:

FOSSILS FROM THE RICHMOND STRATA ON ROCK RUN

Anaphragma mirabile U. & B. (r)
Arthroclema angulare Ulr. (r)
Batostoma prosseri C. & G. (r) W. L.
Bythopora delicatula (Nich.) (r-c) W. L. Wh.
Bythopora meeki (James) (a) W. L. Wh.
Coeloclema oweni (?) (James) (r)
Dicranopora emacerata (Nich.) (r) Richmond
Eridotrypa simulatrix Ulr. (r-c) W
Favositella epidermata (Ulr.) (r) Fernvale
Helopora imbricata Ulr. (r-c) Fernvale
Hemiphragma imperfectum (Ulr.) (r-c) Fernvale
Mesotrypa patella (Ulr.) Wh
Nicholsonella cumulata (r) Fernvale
Nicholsonella punctata (Whit.)
Pachydictya fenestelliformis (Nich.) (c) W. L.
Pachydictya firma Ulr. (c) Fernvale
Pachydictya gigantea Ulr. (a) Fernvale
Pachydictya sp. (c)
Petigopora sp. (r)
Rhombotrypa quadrata (Rom.) (a) W. L. Wh.
Dinorthis subquadrata (Hall) (c) L. Wh.

Dinorthis proavita Winch. and Schuchert (c) Fernvale
Hebertella insculpta (Hall) (c) W.
Platystrophia cumingsi McE. (c) W.
Plectorthis kankakensis (McC) (c)
Plectambonites sericeus (Sowerby) (c) W. L.
Rafinesquina alternata (Emmons) (c) Richmond
Rhynchotrema capax (Conrad) W. L. Wh.
Rhynchotrema perlamellosum (Whit.)
Strophomena neglecta (James) W.
Strophomena planumbona (Hall) W. L.

The species of fossils in the above list leave no doubt of the Fernvale age of the lower or limestone part of the Richmond section in the Rock Run locality.

Along the banks of Aux Sable creek for a distance of one and one-half to two and three-fourths miles northwest of Minooka, Illinois, fossiliferous strata belonging in the middle part of the Richmond, as there developed, are exposed in several places. They consist of alternating layers of shell limestone and calcareous shale in the lower part, grading upward into rather dense granular limestone; the strata are nearly horizontal, the entire thickness seen aggregating 10 to 15 feet. The species of fossils collected from this limestone along Aux Sable Creek are listed below:

LIST OF FOSSILS FROM LIMESTONE ALONG AUX SABLE CREEK, NORTHWEST OF MINOOKA

Amplexopora ampla U. & B. (r)
Batostoma sp. (r)
Bythopora delicatula (Nich.) (r) W. L. Wh
Bythopora meeki (James) (aa) W. L. Wh.
Bythopora striata Ulr. (r) W.
Eridotrypa simulatrix Ulr. (r) W.
Hallopora cf. onealli (r)
Hallopora subnodosa (Ulr.) (c) Richmond
Hallopora cf. subplana (r)
Homotrypella rustica Ulr. (c) W. L. Wh.
Homotrypella rustica var. (c)
Mesotrypa orbiculata C and G. (r-c) A
Stigmatella crenulata U. & B. (r) W.
Stigmatella interporosa U. & B. (r) W
Stigmatella nicklesi U. & B. (r)
Stigmatella spinosa U. & B. (r) W.
Stigmatella spinosa yorkvillensis (c)
Stomatopora arachnoidea (Hall) (c)
Dalmanella testudinaria (Dalman) (c)
Dinorthis subquadrata (Hall) L. Wh.
Dinorthis proavita (Winchell and Schuchert) (r)
Hebertella insculpta (Hall) (r) W.
Hebertella occidentalis (Hall) (r) L. Wh.
Platystrophia cumingsi McE. (r) W.
Plectorthis kankakensis (McC.) (r)

Rafinesquina alternata (Emmons) (c) Richmond
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema periamellosum (Whit.) (c)
Strophomena neglecta (James) (c) W.
Strophomena planumbona (Hall) (c) W. L.
Strophomena planodorsata Winchell and Schuchert (c)
Zygospira modesta Hall (c) Richmond
Pterinea demissa (Conrad) (c) Richmond
Cyclonema sp. (c)
Calymene meeki Foerste (c) Richmond
Isotelus maximus Locke (c)
Synhomalonotus christyi (Hall) (c) W.

In the above list of fossils there are ten species that are not known to occur in Indiana in rocks younger than the Waynesville division of the Richmond, and all but one of these are there restricted to this division. There are no other species in this list that are confined to a single division of the Richmond in Indiana. There can be no doubt that they represent about the same time of deposition as the Waynesville beds of Indiana, and that the fauna corresponds with that of the Fernvale at Wilmington, above described. The species of trilobites, Isotelus maximus and Synhomalonotus christyi, occur in the lower more shaly strata, and are not found in the uppermost limestone layers.

A fauna similar to that occurring along Aux Sable Creek is present in the Richmond strata near Oswego in Kendall county, 15 miles farther north. A practically complete section of these strata, from the contact at the top with the Silurian limestone, is exposed along Fox River between Oswego and Yorkville. The detailed section is as follows:

SECTION OF RICHMOND STRATA BETWEEN OSWEGO AND YORKVILLE

	Ft.	In.
Silurian system		
Limestone, yellowish-gray, partly dolomitic in layers 2 to 4 inches thick	2	4
Ordovician system		
Richmond shale and limestone		
Shale, greenish, thin bedded, without fossils	..	3
Limestone, subcrystalline, in uneven layers 7 to 10 inches thick, with many fossils	6	..
Limestone, bluish, shaly	2	..
Shale, blue	..	3
Limestone, bluish, slightly shaly, in layers 1 to 8 inches thick, with occasional shale partings 4 to 6 inches thick	4	..

	Ft.	In.
Limestone, shaly, bluish, with bands of shale at different levels, containing many fossils....about	10	..
Shale, in bands 3 to 6 inches thick, alternating with limestone layers of about the same thickness, containing very many fossils.....	12	..
Shale, dark, calcareous, containing many shells of species of Dalmanella, Rafinesquina, Pterinea, Isotelus, and Synhomalonotus.....	2	..
Concealed .....about	5	..

The fossils from the strata described in the last section are listed below:

LIST OF RICHMOND FOSSILS FROM ALONG FOX RIVER BETWEEN OSWEGO AND YORKVILLE

Arthropora shafferi (Meek) (r)
Batostoma prosseri C. & G. (r) W. L.
Batostoma varians (James) (c) W. Wh. L.
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (r) W. L. Wh.
Bythopora striata Ulr. (c) W.
Hallopora,cf. onealli (r)
Hallopora subnodosa (Ulr.) (r) Richmond
Hallopora cf. subplana (r)
Homotrypella rustica (r) W. L. Wh.
Perenopora decipiens Rom. (c) A. E.
Stigmatella spinosa U. & B. (r) W.
Stigmatella spinosa var. (c)
Dalmanella testudinaria (Dalman) (c)
Dinorthis subquadrata (Hall) (r) L. Wh.
Hebertella insculpta (Hall) (r) W.
Hebertella occidentalis (Hall) (r) L. Wh.
Lingula deflecta Winchell and Schuchert, (r)
Plectambonites sericeus (Sowerby) (c) W. L.
Platystrophia cumingsi McE. (c) W.
Rafinesquina alternata (Emmons) (a) Richmond
Rhynchotrema capax (Conrad) (c) W. L. Wh.
Strophomena neglecta (James) (r) W.
Strophomena planodorsata W. and S. (c)
Strophomena planumbona Hall (c) W. L.
Zygospira modesta Hall (c) Richmond
Byssonychia radiata (Hall) (c) Richmond
Pterinea sp.
Tentaculites oswegoensis M. and W. (c)
Calymene meeki Foerste (c) Richmond
Synhomalonotus christyi (Hall) (c) W.
Isotelus maximus Locke (c)

In the foregoing list there are six species that in Indiana occur only in the Waynesville formation, and not a single one is present that in Indiana is diagnostic of a younger Richmond horizon.

About 35 miles still farther northwest, strata of Richmond age are exposed along a stream 1½ miles west and ¼ mile north of Kingston, in DeKalb County. The strata at this locality consists of impure shaly

limestone which outcrops in the creek bank to a height of 8 to 10 feet. The horizon is not many feet below the base of the Silurian which was encountered in a water wall put down near the outcrop. The fossils collected at this locality include the species listed below:

FOSSILS FROM THE UPPER PART OF THE RICHMOND NEAR KINGSTON, ILLINOIS

Amplexopora sp. (c)
Arthropora shafferi (Meek) (r)
Batostoma sp. (c)
Bythopora delicatula (Nich.) (r) W. L. Wh.
Bythopora meeki (James) (a) W. L. Wh.
Bythopora striata Ulr. (r) W
Hallopora subnodosa (Ulr.) (a) Richmond
Hallopora cf. subplana (c)
Perenopora decipiens Rom. (c) A. E.
Stigmatella spinosa U. & B. (c) W.
Stomatopora arachnoidea (Hall) (a) W.
Lingula sp.
Dalmanella testudinaria (Dalman) (c)
Rafinesquina alternata (Emmons) (c)
Pterinea sp.
Calymene meeki Foerste (a)
Isotelus maximus Locke (c)
Synhomalonotus christyi (Hall) (a) W.

An exhaustive collection of fossils was not attempted at this place on account of their poor preservation, but the species indicate clearly the Waynesville division of the Richmond, and show also the close correspondence of the Richmond at this locality with that in the vicinity of Oswego, and northwest of Minooka. The trilobites, Isotelus maximus and Synhomalonotus christyi, came from a level a few feet below the upper, more calcareous strata from which the greater number of the bryozoa species were collected, as they did in the Fox River and Aux Sable Creek localities.

West of the LaSalle anticline in the northwest part of Illinois, the lower Richmond (Maquoketa) shale is well exposed in a cut along the Illinois Central Railroad a short distance west of the station at Scales Mound, in Jo Daviess County, where it is immediately underlain by Galena limestone. The detailed section is given below:

SECTION OF RICHMOND STRATA AT SCALES MOUND, ILL.

	Ft.
Maquoketa shale	
Shale, bluish-gray, without fossils	32
Shale, blue, with a reddish zone near the base, and another about 8 feet above the base; containing several small fossils.	11
Galena limestone	
Dolomite, yellowish-brown, in layers 6 to 18 inches thick	6

The following species of fossils were collected from the lower portion of the shale exposed in the railroad cut at Scales Mound. These are peculiar in that they are all of small size, and consist mainly of mollusks. Brachiopods, and especially bryozoa, are exceedingly rare.

LIST OF FOSSILS FROM THE LOWER PART OF THE MAQUOKETA SHALE AT SCALES MOUND

Dalmanella testudinaria (Dalman) (c)
Zygospira modesta Hall (c) Richmond
Ctenodonta fecunda (Hall) (c)
Ctenodonta obliqua (Hall) (c)
Clidophorus neglectus Hall (c)
Bellerophon sp.
Liospira micula (Hall) (c)
Lophospira pulchella Ulrich and Scofield (c)
Pleurotomaria depauperata (Hall) (c)
Orthoceras sociale Hall (a)

The fauna listed above is conspicuous in that it is not a typical Richmond fauna. Only one of the species, Zygospira modesta, is listed by Cumings from the Richmond strata of Indiana, and that has a wide range, both geographical and vertical, and is of no value in stratigraphy. The fauna resembles the lower Maquoketa fauna found near Graf, in Dubuque County, Iowa, and doubtless represents a corresponding horizon.

In the vicinity of Scales Mound, the Maquoketa formation, above the shale exposed in the railroad cut, consists of 50 to 75 feet of bluish-gray, non fossiliferous shale in which are occasional thin bands of earthy dolomite. This is overlain by about 28 feet of alternating layers of calcareous shale and limestone that contain numerous fossils among which are many bryozoa. These upper, calcareous and fossiliferous beds outcrop along the wagon road two and one-half miles northeast of Scales Mound, near the west side of sec. 19, T. 29 N., R. 3 E. from which locality the fossils listed below were collected.

LIST OF FOSSILS FROM UPPER MAQUOKETA STRATA 2½ MILES NORTHEAST OF SCALES MOUND

Amplexopora sp. (a)
Batostoma sp. (a)
Bythopora meeki (James) (r) W. L. Wh.
Constellaria polystomella (Nich.) (r-c) W. L.
Corynotrypa inflata (Ulr.) (c) Richmond
Dicranopora emacerata (Nich.) (r) Richmond

Eridotrypa sp. (c)
Hallopora ramosa (d'Or.) (c)
Hallopora subnodosa (Ulr.) (c) Richmond
Monotrypa sp. (a)
Nicholsonella sp. (c)
Pachydictya fenestelliformis (Nich.) (r) W. L.
Peronopora decipiens (Rom.) (r) A. E.
Rhombotrypa crassimuralis (Ulr.) (r-c) Fernvale
Stomatopora arachnoidea (Hall) (c)
cf. Glyptocrinus decadactylus Hall (r)
Dalmanella testudinaria (Dalman) (c)
Hebertella insculpta (Hall) (c) W.
Dinorthis proavita Winchell and Schuchert (c)
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis whitfieldi (Winchell) near P. kankakensis (McC) (c)
Rafinesquina alternata (Conrad) (c) Richmond
Rhynchotrema capax (Conrad) (c) Richmond
Rhynchotrema neenah (Whitfield) (c)
Strophomena neglecta (James) (c) W.
Strophomena wisconsinensis Whitfield (r)
Modiolopsis concentrica Hall and Whitf. (c) W.
Hormotoma sp.

The species of fossils in the foregoing list indicate the same horizon as that which furnished the fossils from Aux Sable Creek, and that in the vicinity of Oswego, and Wilmington. Three of the species in the list are restricted to the Waynesville division of the Richmond in Indiana, and not one of them is confined to any other member of the Indiana Richmond. The only species in the list that were not found in the Wilmington, Oswego and Aux Sable Creek localities are Corynotrypa inflata, which ranges throughout the Richmond, Hallopora ramosa, which occurs in the Maysville of Indiana, and Modiolopsis concentrica, which is restricted to the Waynesville formation in the Ohio-Indiana region. These upper Maquoketa strata are thought to represent Waynesville time, and to correspond in age with the Fernvale limestone present at Wilmington, and in the vicinity of Oswego, and northwest of Minooka.

Another excellent exposure of the upper strata of the Maquoketa is in the north bank of Rock River, one and one-fourth miles east of the railroad station at Sterling, Illinois. The detailed section of the outcrop at this place is given below:

SECTION OF STRATA EXPOSED IN THE NORTH BANK OF RIVER 1¼ MILES EAST OF STERLING

	Ft.
Silurian limestone	
Limestone, yellow to brown, dolomitic, in layers 4-10 inches thick, with few fossils	28

Maquoketa shale	Ft.
Shale, bluish-gray, in layers 3 to 6 inches thick, alternating with calcareous, very fossiliferous bands	10
Shale, sandy with few fossils	18

The species of fossils collected from the upper member of the Maquoketa at this place are listed below.

LIST OF FOSSILS FROM 1¼ MILES EAST OF STERLING, ILL.

Anolotichia sp. (r)
Anaphragma mirabile U. & B. (c)
Batostoma prosseri C. & G. (c) W. L.
Batostoma varians (James) (c) W. L. Wh.
Bythopora delicatula (Nicholson) (c) W. L. Wh.
Bythopora meeki (James) (c) W. L. Wh.
Bythopora striata Ulr. (r-c) A.
Dicranopora emacerata (Nich.) (r) Richmond
Dicranopora fragilis (Bill.) (c)
Favositella epidermata (Ulr.) (r)
Hallopora subnodosa (Ulr.) (r) Richmond
Hallopora cf. subplana (Ulr.) (r)
Hemiphragma imperfectum (Ulr.) (c)
Mesotrypa sp. (r)
Nicholsonella sp. (c)
Rhombotrypa quadrata (Rom.) (c) W. L. Wh.
Stomatopora arachnoidea (Hall) (c)
Dalmanella testudinaria (Dalman) (c)
Hebertella insculpta (Hall) (c) W.
Hebertella occidentalis (Hall) (c) Richmond
Leptaena unicosata (Meek and Worthen) (c)
Platystrophia cumingsi McE. (c) W.
Plectambonites sericeus (Sowerby) (c) W. L.
Plectorthis whitfieldi (Winchell) near P. kankakensis (McC) (c)
Rhynchotrema capax (Conrad) (c)
Rhynchotrema neenah (Whitfield) (c)
Strophomena neglecta (James) (c) W.
Strophomena planodorsata Winchell and Schuchert (c)
Strophomena planumbona Hall (c) W. L.
Byssonychia radiata (Hall) (r) Richmond
Bellerophon sp.
Cyclonema sp.
Tentaculites sterlingensis (M. and W.) (c)

The species of fossils in the above list clearly represent a fauna that corresponds with that from the upper Maquoketa strata northeast of Scales Mound, and with those found in the Richmond strata along Aux Sable Creek, in the vicinity of Oswego, and at Wilmington. Four of the species do not occur above the Waynesville beds in Indiana, and not one of them is restricted to a post-Waynesville formation in the Richmond of Indiana. On the Mississippi River, at Savanna, Illinois, 30 miles northwest of Sterling, the Upper Maquoketa strata also consist of alternating shale and limestone layers which furnished fossils similar to the species listed from east of Sterling, and certainly represent a corresponding

horizon. In some places in northern Illinois and northeastern Iowa the upper, very fossiliferous beds of the Maquoketa were removed by erosion before the overlying Silurian strata were deposited. In other places a thickness of 25 to 50 feet of non-fossiliferous shale overlies this calcareous, and very fossiliferous horizon. The latter can be traced clearly from northern Illinois across the northeast part of Iowa, in spite of the erosional unconformity at the top which results in different levels of the Maquoketa occurring immediately beneath the Silurian limestone.

An excellent outcrop of these upper Maquoketa strata occurs along a stream 7 miles west of Preston, in Jackson County, Iowa, where the following section was made:

SECTION OF STRATA EXPOSED 7 MILES WEST OF PRESTON, IA.

	Ft.
Silurian limestone	
Limestone, dolomitized, in rather even layers 4 to 12 inches thick, containing few fossils	40
Maquoketa shale	
Shale, bluish-gray, in thin layers. Those in the upper part alternating with limestone bands, containing many fossils	35

The following species were collected from the Maquoketa shale at this locality:

FOSSILS FROM THE UPPER PART OF THE MAQUOKETA, 7 MILES WEST OF PRESTON, IA.

1. Anolotichia sp. (r-c)
2. Anaphragma mirabile ? (c)
3. Batostoma sp. (c)
4. Bythopora meeki (James) (r) W. L. Wh.
5. Ceramoporella ohioensis (Nich.) (r) Richmond
6. Coeloclema sp. (r)
7. Corynotrypa inflata (Hall) (c) Richmond
8. Eridotrypa simulatrix (r) W.
9. Hallopora subnodosa (Ulr.) (c) Richmond
10. Hallopora sp. (c)
11. Homotrypella rustica ? (r) W. L. Wh.
12. Mesotrypa sp. (c)
13. Peronopora decipiens (Rom) (r) A. E.
14. Petigopora sp. (c)
15. Stigmatella spinosa (r) W.
16. Stigmatella sp. (c)
17. Stomatopora arachnoidea (Hall) (r)
18. Rhombotrypa quadrata (Rom.) (r) W. L. Wh.
19. Rhombotrypa subquadrata (Ulr.) (r) W. L.
20. Streptelasma rusticum Billings (r) W. L. Wh. E.
21. Dalmanella tersa Sardeson (r)
22. Dalmanella testudinaria (Dalman) (c)
23. Dinorthis subquadrata Hall (r) L. Wh.

24. Hebertella insculpta (Hall) (c) W.
25. Hebertella occidentalis (Hall) (c) Richmond
26. Leptaena unicostata (Meek and Worthen) (c)
27. Plectambonites sericeus (Sowerby) (c) W. L.
28. Plectorthis whitfieldi (Winchell) near P. kankakensis (McC) (c)
29. Rafinesquina alternata (Conrad) (c) Richmond
30. Strophomena neglecta (James) (c) W.
31. Stromphmena planumbona (Hall) (c) W. L.
32. Byssonychia radiata (Hall) (r) Richmond
33. Modiolopsis concentrica (Hall and Whitf.) (r) W.
34. Pterinea demissa (Conrad) (r) Richmond
35. Conradella sp.
36. Cyclonema sp.
37. Hormotoma sp.
38. Liospira sp.
39. Lophospira sp.
40. Tentaculites sterlingensis M and W. (c)

In the fauna from the upper Maquoketa beds seven miles west of Preston, Iowa, there are five species that in Indiana are restricted to the Waynesville formation of the Richmond, and not one of the species is diagnostic of a higher horizon in the Indiana and Ohio Richmond. The fauna clearly corresponds with that from the upper Maquoketa east of Sterling, and with the fauna listed from the localities above described in Illinois. These very fossiliferous upper Maquoketa strata are also well exposed in the bed of a stream where it joins the Mississippi River about two miles south of Bellevue, in Jackson county, and at Patterson's Spring, one mile north of Brainard, in Fayette county, and at several other places in northeast Iowa where they contain a fauna similar to that listed from seven miles west of Preston.

If this correlation is correct, the conclusion follows that the uppermost fossiliferous strata of the Maquoketa in Iowa and northwest Illinois are of Fernvale age, and they represent the time of Waynesville deposition in Indiana and Ohio. The earlier Maquoketa strata in Iowa lack many of the characteristic early Richmond species of fossils present in Indiana and Ohio, and they contain a number of species that are more distinctly northwest Richmond forms such as Dicranopora fragilis, Dinorthis proavita, and Leptaena unicostata, that do not occur in the Indiana-Ohio basin. It is thought that the sea in which the lower and middle Maquoketa strata were deposited advanced from the northwest into Iowa and

northwest Illinois, and adjacent portions of Minnesota and Wisconsin. During upper Maquoketa time this sea was joined by the transgression toward the northwest of the Fernvale sea from the south during lower Waynesville time.

Foerste[1] has shown that the oldest Richmond deposits in the Ontario and Quebec region are of upper Waynesville age, and contain, among others, such species as Stromatocerium huronense, Tetradium huronense, Columnaria alveolata, Calapoecia huronensis, Catazyga headi, Strophomena sulcata, and Zygospira kentuckiensis. It is very significant that not one of these species occurs in the Fernvale or Maquoketa of Illinois, Iowa, Minnesota, or Wisconsin. It is thought that the great transgression of the sea in Waynesville time, in which the Fernvale sediments were deposited in the Mississippi valley basin, was from the south, and that it occurred before the oldest Richmond fauna of the Ontario-Quebec region had reached the Ohio-Indiana area.

CONCLUSION

The fauna of the uppermost calcareous strata of the Richmond in northeast Illinois, and of the Maquoketa in northwest Illinois, Iowa, Minnesota, and Wisconsin indicates that these strata are of Waynesville age. They also show that the Fernvale limestone of northeastern and southern Illinois is of practically the same age as the Waynesville. This Fernvale-Upper Maquoketa sea is thought to have advanced from the south, since strata of corresponding age are known to the south in Monroe and Alexander counties in Illinois, and in southern Tennessee, and they are not known in the northern part of the continent.

During early Richmond (pre-Waynesville) time, it is thought that a sea advanced from the northwest into the upper Mississippi valley, in which were laid down the sediments comprising the lower and middle Maquoketa strata of Iowa, Minnesota, northwest Illinois and Wisconsin. During lower or middle Waynesville time, a southern sea invaded the Mississippi valley and Ohio

[1] Foerste, Aug. F., Upper Ordovician formations in Ontario and Quebec. Geol. Surv. of Canada, Memoir 83, 1916.

basins in which there accumulated the sediments that make up the Fernvale limestone. This sea transgressed far to the north and northwest, overlapping the former areas of Maquoketa, and united with the northern sea in northwest Illinois, northeast Iowa, and Wisconsin and Minnesota. In this sea there was a mingling of the aboriginal or older Maquoketa faunas with the invading faunas from the south. However, the invading species were dominant and left the strongest impress on this youngest fauna of Richmond age in the Maquoketa basin. It is thought that these uppermost calcareous and very fossiliferous strata of the Maquoketa were deposited before the invasion of the sea from the northeast into the Indiana-Ohio basin which occurred during upper Waynesville time. A late Richmond sea advanced from the south into Illinois and Missouri, in which was deposited the Thebes sandstone which rests unconformably upon the Fernvale limestone at Thebes, Illinois, and Cape Girardeau, Missouri. This Thebes sandstone deposition may have taken place at the same time the sandy sediments of the Saluda member were deposited farther east, but it was probably somewhat later. The non-fossiliferous shale that in places overlies the calcareous and fossiliferous horizon in the Wilmington, Minooka, and Maquoketa areas described in this paper was probably deposited at the time of the Thebes submergence.

PAPERS ON MEDICINE AND PUBLIC HEALTH

HUMANIZING MEDICAL EDUCATION

FREDERICK R. GREEN, M. D., CHIEF, EDITORIAL DEP'T OF "HEALTH," CHICAGO

In one of his historical essays, John Fiske says that the increased geographical knowledge of the European world in the fifty years immediately following the discovery of America by Columbus was so great as to require the next two hundred years to digest, assimilate and utilize this knowledge. This statement may with equal truth be applied to our present-day knowledge of the human body and its diseases, their diagnosis, prevention, and treatment. In the last half century, modern medicine and surgery have developed. More has been learned regarding the human body and its diseases than in all the preceding centuries of civilization. Our profession has been so busy learning newly discovered facts that there has been little or no opportunity in this era of analysis and investigation for synthesis or generalization. New discoveries have crowded so fast on each other that there has been no time for taking stock or for adjusting educational methods to meet new conditions. The medical school has, through force of circumstances, become a part of the modern university. But the modern university has become something radically different from the university of yesterday.

In his *"History of Mankind"*, Dr. Henry Van Loon gives an interesting account of the medieval universities. "They were found", he says, "wherever a few teachers and a few pupils happened to find themselves together. Now-a-days, when a new university is built, the process is as follows: Some rich man wants to do something for the community in which he lives, or a particular religious sect wants to build a school to keep its children under supervision, or a state realizes the need of educating doctors, lawyers, and teachers. The university begins as a large sum of money which is deposited in a bank. This money is drawn out to construct buildings and laboratories and dormitories. Finally, professional teachers are hired, entrance examinations are held, and the university is on the way. But in the Middle Ages things

were done differently. A wise man said to himself, 'I have discovered a great truth. I must impart my knowledge to others.' And so he began to preach his wisdom whenever and whereever he could get people to listen to him, like a soap-box orator. If he was an interesting speaker, the crowd came and stayed; if he was dull, they shrugged their shoulders and continued their way. By and by, certain young men began to come regularly to hear the words of wisdom of this great teacher. They brought copybooks with them and little bottles of ink and goose quills, and they wrote down what seemed to them to be important. One day, it rained. The teacher and his pupils retired to an empty basement or to the room of the professor. The learned man sat in his chair and the boys sat on the floor. That was the beginning of the university, the 'universitat'—a college of professor and students in the Middle Ages, when the teacher counted for everything and the building in which he taught counted for very little."

So the university was originally built around a man who had a new idea which he wished to impart to others. It was said in New England a hundred years ago that a college consisted of Horace Bushnell sitting on one end of a log and a student with a Greek textbook on the other. Here were all the essentials for the college of that day—the learned teacher and the responsive student, who by personal contact with his teacher absorbed his wisdom and profited by his experiences. But the modern college teaches more than the "humanities". With the development of the natural sciences in the latter half of the 18th century and the first half of the 19th, and the application of scientific discoveries to industrial life, came the demand for technical training in laboratories and workshops.

Naturally, this had a marked effect on our universities. Law and theology, which consist of principles, precedents and moral maxims, can be taught from textbooks today, just as they were two hundred years ago, but the development of the natural sciences and the addition to the university curriculum of courses in mechanical, electrical, and mining engineering and other technical sub-

jects has made the university of today a great workshop instead of the quiet and secluded retreat which it was a century ago.

On no other profession has this development of modern science had so marked an effect as on the teaching and practice of medicine. In the last hundred and fifty years has developed practically all of our accurate knowledge of physics, chemistry, and biology, the three sciences fundamental to a knowledge of the human body its workings, and diseases. The modern microscope, as perfected by Lister and Amici in 1836, has, in less than a hundred years, developed the new sciences of histology, pathology, biology, and bacteriology. So that instead of a medical training of one or two short courses of lectures, the medical student of today must have the most thorough preparation and must undergo the longest, the most severe and the most expensive training required of any present-day profession.

Medical education has undergone a complete revolution and has produced changes not only in educational methods, but also in the character and type of physician, that have not as yet been fully realized.

During the Colonial period of our history, the only trained physicians in this country were men who had gotten their medical education in England or on the Continent and who had later come to this country. Naturally, such men were few in number. The scarcity of physicians in the growing colonies led to the custom of a young man who desired to become a physician "reading medicine" with an older and established practitioner and fitting himself to treat the sick through personal instruction by his preceptor and the study of the medical textbooks in the physician's library. Such an arrangement was not only the best that could be made under the existing conditions, but it was also by no means an ineffective system of training. The young man of seventy-five years ago who "read medicine" with his preceptor and who, incidentally, took care of the horses, put up and delivered the medicines, and acted as general office boy, while he received a quality of instruction along scientific lines which would not be recognized today by any medical

school, also received something which the medical student of today lacks. He was in constant and every day contact with his preceptor. He saw the patients who came for diagnosis and treatment. He assisted often in their treatment. He rode for miles in the old-fashioned doctor's gig with his teacher, and from the older man, with his years of experience and trained observation, he acquired all of his scientific knowledge and in addition his knowledge of the practical or applied side of medicine as a profession. He learned how to handle not only the patient, but, what is often more difficult, the patient's relatives and friends. He learned not only all that the doctor knew of medicine as a profession, but also all that he knew of medicine as a business. He acquired, in a word, that personal knowledge based on individual experience that can not be taught in laboratories or by textbooks, but that can only be acquired from man to man.

It was this crude but essentially human training which made the old-time family doctor the confidant and father confessor of his patients, as well as the man of influence and leadership in the community, an essential factor in medical education which the highly scientific, thorough and exhaustive present-day medical curriculum has not yet been able to supply. The doctor of fifty years ago was essentially human, even if he was not always highly educated. The doctor of today, with his exhaustive and expensive training, his highly technical ability, his thoroughly equipped office and laboratory, and his equally fully equipped hospital around the corner, is not in as close contact with his patients, either individually or collectively, as his professional forefather of half a century ago who did not have one-tenth of the medical knowledge of today but knew far better how to use, effectively, sympathetically, and understandingly the knowledge which he did possess. The human element is lacking in the training and is consequently lacking in the product.

The story of the development of medical education in this country is an intensely interesting one. But it is not possible at this time to consider it in detail.

The problem today is not how to raise the standard of scientific instruction (that is practically solved), but

how to adapt our present-day educational methods so that the medical graduate of today may be as capable and efficient along practical lines as was his professional forefather of two generations ago, who, with a far less comprehensive and adequate training, was able to exercise a far greater personal influence. Everyone agrees that physicians today do not have the influence or enjoy the public confidence of their predecessors, though they are much better educated and far more capable. How can this confidence be restored without sacrificing our high scientific standards?

The defects of our present-day medical education are widely recognized. At the alumni dinner of the Carnegie Institute of Technology, Dr. Thomas S. Baker, the president, said, "We are giving too much importance to methods and not enough to substance; too much importance to courses of study and not enough to the individual teacher. College and school executives are so enmeshed in a maze of administrative details that they are in danger of building up systems rather than in building up faculties. The greatest need of American education is simplification." Dr. Ray Lyman Wilbur, president of Leland Stanford University and president of the American Medical Association, says, "The social responsibilities of the profession are enormous. Are we going to fit in or be fitted? The social aspects of medicine are inevitable. We need to smash the present curriculum and revamp it to bring it up to the medical requirements of modern knowledge. Present medical courses are in some ways ridiculous. We now take twenty-five years of the life of the best young men in the country preparing them to become physicians. We standardize the work so that when they have finished they are all alike." Dr. Richard C. Cabot of Boston says, "The psychical side of practice is more than half of the practitioner's job and makes or mars him. Men intending to study and practice medicine must face the fact that medical schools give practically no attention to the psychic side of the doctor's work. How to deal with people,—that is the problem. The doctor must learn the

psychology of human approach. This is absolutely necessary in his education, but he is never taught it."

Nor are such views confined to the leaders in medical thought in this country. Sir James Mackenzie, probably the leading English authority on diseases of the heart, in his recent book on *"The Future of Medicine"* says, "The chief difficulty is in the fact that there is no teacher with a broad outlook on medicine who can see all the different branches in their proper perspective. Fifty years ago, progress was being made on certain lines which tended to a clearer conception of what medical education was, because the teachers were men who had taken a broad outlook. At the present day, there is not a single teacher in a school of medicine capable of taking that broad outlook. When any attempt is made to modify the instruction necessary for the general practitioner, every kind of individual connected with education is consulted except the one individual capable of showing from his own experience where medicine fails, that is, the general practitioner himself."

The situation, today, is radically different from that of fifty years ago. In those days, the surgeon taught anatomy, operative surgery, surgical diagnosis, and operative technique. The medical student who worked with Sir Astley Cooper, John Hunter, Everhard Home, Syme, or any of the other great surgeons of that day, learned from them, not every anatomical fact regarding the human body, which it is not possible for anyone except the professional anatomist to learn or retain for any length of time, but those anatomical facts which are necessary and essential for the proper practice of surgery, and he learned them with an exactness and a thoroughness which remained with him through life. From the same teacher, he learned his surgical diagnosis and his operative technique. He stood beside and assisted him in the operations. He learned the after-care of his surgical patients but, most important of all, he learned from these great leaders not only how to handle surgical conditions, but also how to handle patients suffering from surgical conditions. Just as the student of the early days who "read medicine" with a preceptor learned the

practical and applied side of medicine, so the student of surgery learned courage, self-control, and resourcefulness from the greatest men of his day.

Today, the medical student learns his anatomy from a bachelor or a master of science whose work has been limited entirely to the dissecting-room and the laboratory. He learns his histology from another laboratory man; his pathology from a teacher, most of whose time has been spent in the morgue and in the preparation-room; his physiological chemistry from a professional chemist; his X-ray diagnosis and treatment from the electrical specialist. The eye he studies under an ophthalmologist; the ear under an aurist; the throat and nose under a laryngologist and nervous diseases from a neurologist. Nowhere at any stage of his long, expensive and crowded course is there any opportunity for him to come in contact with some broad mind which will help him to digest this tremendous mass of information pouring in on him from all sides and many sources. Nowhere on the faculty is there a single man who is interested in the problems which will confront the doctor in the first few years of his professional career. Above all, nowhere in the curriculum is any attempt made to tell him anything about the practical, everyday problems which are going to confront him. He is taught all about the human body, but he is taught nothing about human beings.

As a result, he leaves his alma mater, even after an internship in a hospital, loaded down with the very latest knowledge of all the innumerable branches of present-day medicine and surgery, full of information given him by experts who are twenty or thirty years ahead of him in point of experience, equipped with all of the technical knowledge of tests, examinations, analyses, methods of diagnosis and methods of treatment, without having had a single hint during the entire six years of his course as to how he can secure patients on whom to exercise this enormous accumulation of knowledge, how he shall keep them after he has gotten them, or how he can collect enough money from them to pay his professional expenses and make a living for himself and his family. In

a word, the science of medicine is taught today as never before, but practically everything that could possibly help the student to a knowledge of the practice of medicine has been eliminated. He is taught all about medicine except how to practice it.

The result is that the young medical man goes into practice without any clear ideas of the relations between himself and his patients individually; between the doctor and the public, either individually or as a class; between the doctor and his professional associates. No one has told him of such things in medical schools. He soon gets some amazing shocks. He believes that the so-called "regular" school, to which he of course belongs, is not only the only one which has a right to exist, but the only one which is accepted by the public as reputable or honest. Yet he sees great lawyers, judges and business men patronize osteopaths and chiropractors, Christian Science healers and nature doctors. Naturally, he is confused and irritated. He was taught nothing in his medical course regarding the history or development of his profession, and, of course, nothing regarding the numerous sects, cults and so-called schools of medicine which have always existed. He knows, in a contemptuous and superior way, that homeopaths believe in "similia similibus curantur" and that the only medicine they are supposed to give is little sugar-coated pills. He knows that Christian Science was founded by Mrs. Eddy. He knows that osteopathy and chiropractic consist in using massage or some modification of it in strange and wild ways, but who is responsible for these sects, how they originated and why intelligent people support them, he does not know. He has never been told anything about the history of sectarianism or its various manifestations. He regards all sectarians as quacks and fakirs and looks with contempt on any layman who would patronize them.

He feels, and rightly, too, that a medical man should be judged by the quality of his work, the standing of the college from which he graduated, and the hospital in which he served as an intern. He can not understand why intelligent laymen should pass him by and patronize a Christian Science healer or a nature doctor. He is

amazed, hurt, and disappointed because no one has ever told him anything about popular psychology, the eternal appeal of the charlatan or pseudo-scientist. His college professors should have told him something about the various cults and sects and how to meet them, but they were all far too busy lecturing on pure science to waste time on such absurd subjects. So he has to learn by hard knocks because no one has ever told him how his own profession reached its present state.

When the young practitioner considers his legal status, he is also puzzled. He believes that his diploma, and especially his state license, constitute him a privileged individual, and that he is "recognized by the state," whatever that may mean. He believes that a medical practice act exists for the purpose of protecting him from competition by preventing everybody except regular physicians from treating the sick. He regards all health laws as commendable or desirable. If some of these laws impose compulsory restrictions on laymen, it is necessary for them to submit for the public good. He views compulsory vaccination and quarantine regulations as perfectly proper restrictions on the layman. So far he is right. But when the state or federal government imposes regulations or restrictions on him, in the form of laws for the restriction of the use of alcohol or habit-forming drugs, his wails of protest are heard afar, because his professional and personal liberty is thereby interfered with. No one ever told him in his medical course that medical practice acts are for the protection of the people and not the doctor, and that his cherished state license is in no sense a "recognition" or endorsement but is simply a police permit to do business and legally is in the same class with an automobile license. So again he has to learn by hard experience or remain in ignorance, because no one has ever told him anything about his legal relations.

Early in his practice, the young doctor comes in contact with some one of the many medico-social bodies which have developed so numerously in the last twenty-five years. The Red Cross, the National Tuberculosis Association, the Cancer Society, the Society for the Pre-

vention of Blindness, ask him to support them or work with them. Again, he is confused. What are laymen doing in the field of medicine? What ought they to do? What should be the doctor's attitude to such bodies? What are the social relations of the doctor and the medical profession? What is State Medicine and what effect will it have on him? What are Health and Industrial Insurance? What is Contract Practice? What shall he do about all these things that surround him every day and that his teachers never told him about? He doesn't know because during all the years of his training he never knew there was such a thing as medical sociology —that great field that has developed so rapidly in the last twenty years. His teachers were all too busy to tell him anything about it. And again he has to suffer because no one has told him.

Then practical and financial questions arise. How much should he charge for his services? How can he collect his accounts? Who is liable, in complicated and perplexing cases, for payment for his services? How can he, an expensively and thoroughly educated technician, develop into a successful business man, as well? He has the technical training for his work. How can he succeed as a practitioner? Has any one told him? No. There is not a medical school in this country where any instruction is given on how to practice medicine as a business. Yet the most highly trained man will be a failure and a dead loss to himself and society unless he can make enough to support himself and family, pay his bills, and save enough for postgraduate work and invest enough to secure him for old age. Is any medical school teaching medical economics? If they are, it isn't mentioned in the catalogues. Yet the business side of a profession is quite as important as the technical side, if one is to be successful. The practical advice that the medical student formerly got from his old preceptor has no counterpart in the present-day medical curriculum. He not only makes mistakes but he loses money because no one has ever told him how to manage his business.

After the young doctor has been in practice for anywhere from one to five years, some other doctor asks him

to join a medical society. This is the first time he has heard it mentioned. In the last twenty-five years, our medical organizations have increased in membership, efficiency and influence more than in the preceding seventy-five years. Has the medical student been told anything about medical organizations, their purposes and advantages, and that it is his duty and privilege to join the county, state, and national bodies just as soon as he is eligible? Not that I have ever heard. I recently had occasion to talk to a senior medical student of one of the leading medical schools of the country. In the course of the conversation, I mentioned the American Medical Association. To my surprise, he hadn't the slightest idea what it was. I said to him, "In the four years you have been in college have you never heard the American Medical Association mentioned?" He said, "No, Doctor, except I remember one spring one of our professors dismissed his class early because he had to catch a train to go the American Medical Association meeting, but I hadn't any idea what it was. That's the only time I heard it mentioned."

Christ said to his disciples, "The children of this world are wiser in their day and generation than the children of light." B. J. Palmer, the founder of chiropractic, may be short in science but he's long in common sense. Every student who matriculates at the Davenport Chiropractic School joins the National Chiropractic Association the day he enters the school. We let four thousand of the brightest and best trained of young men spend from four to seven years in school studying medicine, and send them out to become the doctors of the future and never tell them a word about our own organizations. After they have had four or five hard years of bumps and mistakes we go around and try to organize them. Brilliant idea! But why not begin to organize the medical profession at the door of the medical school? Common sense, isn't it?

Finally, after enduring all the knocks and rude awakenings incident to the first years of practice, comes the last straw. The young doctor is sued for malpractice. It may be inspired by a jealous business rival, stimulated

by a firm of ambulance-chasing lawyers, brought by a dead-beat patient to scare the doctor from collecting his bill, or the consequence of an unforseen but unfortunate outcome of a complicated fracture or a wilful and disobedient patient. Does the doctor know his own rights, responsibilities, and liabilities before the law, so that he can protect his own interests? Not from anything he has learned in college. Yet the principles of the common law as applied to professional responsibility are comparatively simple and could easily be presented in such a way as to be of enormous value to the student. "But," you say, "most medical colleges give a course in medical jurisprudence." True. But most, if not all the time for such a course is devoted to criminal law and the legal aspects of insanity. Few doctors, even after they have been practicing for years, have any clear ideas regarding a physician's rights, obligations, and responsibilities as applied to the problems of everyday practice.

What does the student learn in our present-day medical school? He learns the science of medicine. Nowhere, so far as I know, has any attempt been made to teach him or even advise him on the applied art of the practice of medicine. When the University of Pittsburgh Medical School, a few years ago, decided, what was perfectly true, that their graduates were being turned out without any knowledge of the history of their profession, a course in medical history was added to the curriculum. But who gave the course? The professor of history in the University, a non-medical man, whose only knowledge of the history and development of the medical profession was gained from textbooks. In order to cure the danger of specialism, another specialist was added.

Our present-day medical curriculum, then, is deficient in that it lacks a humanizing influence at three points of contact.

First, the instruction, today, is exclusively by specialists, each interested in his particular line. The student does not anywhere come in contact with a broad, highly trained mind, capable of synthetizing the entire field of medical knowledge for him, adding the experience and practical knowledge that has been gained through years

of effort, giving the medical student the sound, practical advice which he needs, especially in the first few years of his medical career. There is nothing in our present medical curriculum to bridge the gap between the medical student of today and the well-grounded medical practitioner of ten years from now.

Second, the student, both in college and in the hospital, looks on the patient simply as one unit in a large mass of clinical material. Himself a machine-made product, with but little individuality in his training, he regards the patient in much the same light. Nowhere is he taught to consider the patient in the hospital or in the clinic as an individual entity which he must learn to understand quite as thoroughly as he does the disease from which the individual patient is suffering. He is taught to treat diseases rather than human beings.

Third, and most important of all, the medical student at no time during his four-year course receives any instruction or even any advice regarding his own individual place in society, his relation to his patients, the public, or the medical profession as a whole, the personal relations of the medical profession, or how the present-day situation came about. Yet all this knowledge, which would make possible an entirely different social viewpoint from that now held by most physicians, could be made a valuable part of the present-day medical curriculum. Even if it were necessary to sacrifice some of the numerous specialties which now occupy so much time, such a course would be well worth the while. But such a sacrifice is not necessary. One hour a week, during the four-year course, is ample for this purpose.

During the first or freshman year and before the student has had his mind distracted by a multitude of other subjects, one hour a week, throughout the freshman year, should be given to the history of medicine. This important subject should be taught, not in the perfunctory and dry manner in which most historical matter is presented, not in the fragmentary and divided way in which some of the special departments present the history of their own subject. It should rather be given as a series of informal talks on the early history and development of

medicine among primitive peoples; its growth among the Greeks, the Jews, the Egyptians, the Romans, and the Arabians; its condition and limitations during the Middle Ages; with a summary of the important advances which were made; an account of the development of the natural sciences in the 17th and 18th centuries and the influence of the development of physics and chemistry on medicine; an account of the slow development of the microscope and its final perfection; of the influence which this discovery had on biology; of the development of organic chemistry by Liebig; of cellular pathology by Virchow; of bacteriology by Pasteur; and of present-day surgery by Lister; of the marvelous development of the last fifty years and of the men who made this development possible, with a summary of the leading men in the different fields who are at present regarded as leaders. Such a course would not only be intensely interesting, if illustrated with lantern slides and moving picture films, but it would also give the young medical student the historical background which he is, today, entirely lacking.

In connection with each epoch or period of medical development, attention would be called to the different sects, cults, and schools which prevailed at that time. Most physicians, I have found, are familiar with and bitterly hostile to the cults of their own day, which they regard as entirely unique, present-day phenomena. They do not realize that every period in medicine has had its own peculiar brand of pseudo-medicine; that every generation has had its fads and its sects; that before the chiropractor was the osteopath; before the osteopath, the eclectic; before the eclectic, the botanical doctor and the Thompsonian; before that, the homeopath; before Hahnemann, the Perkins' tractors, Bishop Berkeley's tar-water, and the stone extractors of previous generations. There has always been the sectarian, the faddist, and the follower of fantastic cults. Attempt to suppress him is the breath of his nostrils and only gives him so much free advertising. The only way to combat him is to learn his own particular fad more thoroughly than he knows it himself so that he can be the more readily refuted and discountenanced. This would

avoid the spectacle which we often see of learned physicians, known throughout the country, appearing before legislative committees and being made monkeys of by shrewd, adroit quacks who did not have a fraction of their knowledge but far exceeded them in ability to present a subject to a lay audience.

In the second year, an equal amount of time—one hour a week—should be devoted to a discussion of the social side of medicine. Under this head would be discussed the relation of the individual physician and the medical profession to society as a whole, both in previous generations and today; a discussion of the relation of the medical profession to other professions, as lawyers, ministers, etc.; the relation of the allied professions of dentistry, pharmacy, trained nursing, and the midwife; the growth of the social public health movement of the last twenty-five years, including such organizations as the National Tuberculosis Association, the American Society for the Control of Cancer, the American Child Health Association, and all of the other organizations, nearly one hundred in number, which have developed in this field since the beginning of the present century. The lack of reliable knowledge on these subjects has not only caused much confusion and division of opinion among physicians, but has prevented the profession from exerting its united influence for the guidance of public opinion and the protection of the public health, as well as its own legitimate interests.

In the third year, an hour a week should be devoted to the economic side of medical practice. Business methods, systems of bookkeeping, and cost accounting, correct methods of charging and collecting, as well as advice on investments, would be taken up. Here, also, would be discussed the advantages and disadvantages of government service, the Army, Navy, and United States Public Health Service, public health and industrial work, as well as such important economic problems as health insurance, contract practice, fee splitting, group practice, etc.

The fourth, or senior year, should have an hour a week devoted to the instruction of the graduating class in medi-

cal ethics and organization for half the year, the remain der to be devoted to a course of lectures on medico-legal problems of the physician, telling the men about to enter the actual practice of medicine what the law provides and the courts have ruled regarding a physician's rights and special privileges, liability for professional services, the law of expert testimony, of malpractice, of privileged communications, of birth, death, and marriage registration, of legitimacy, insanity and criminal procedure, so far as it touches the everyday problems of medicine. Only one who has followed the subject for many years has any idea how diverse and perplexing are the problems that arise in the physician's daily life, how sorely he needs advice on these problems and how to meet them, and how much annoyance he could be spared by practical instruction at the beginning of his professional career.

The adoption of such a course, covering a large and important list of subjects not found today in any medical curriculum, would only require one hour a week throughout the four years. It would not be necessary to omit or greatly curtail any of the courses now being offered. In the hands of a teacher who understood his subject and who put into it vitality and human understanding, it could easily be made one of the most valuable and popular courses in the entire schedule.

It is impossible to turn back the hands of time. The old preceptor with his wise, kindly, practical advice is gone forever. Our medical schools are today giving better, more scientific and valuable training than ever before. But with all their highly specialized courses, expensive laboratories, and expert teachers, they fail to provide any substitute for the old preceptor or any humanizing touch by which the medical graduate of today is qualified to deal with and solve not only scientific problems, but human problems as well. If to the thoroughness and accuracy of the present-day curriculum the saving grace of personality and human experience can be added, the medical graduate of tomorrow can begin his professional work with a far greater assurance of real success than is possible today.

Universities are something more than buildings; teaching is something more than laboratory equipment; professional training, in the highest sense, is more than technical instruction. Our medical schools must not be satisfied with anything short of that training which is not only of the highest scientific quality, but also of the broadest practical value. While the curriculum in our medical schools today is perhaps more crowded and overweighted than that of any other course of technical instruction, a place must be made in the four-year medical course for instructing the physician of the future in the spirit as well as in the letter of his work. He must be told the history of his profession, not in a perfunctory recital of names and dates, but so as to make him understand the heritage of effort, experience, knowledge and sacrifice which the great men of previous generations have handed on to him. He must be taught his duties and his responsibilities to his patients and to his community with as much care as he is now instructed in anatomy, bacteriology, and chemistry. He must be shown his duty and his responsibility to his profession and to his individual professional associates, and he must be given as sound instruction in the business of his profession as he is now given in its science. In a word, he must be taught the vastly increased scientific knowledge of today, plus the practical, personal inspiration of the old system, so that each graduate of our vastly improved medical colleges of today may be not only the best trained man in his community, but also the man with the largest, broadest, and deepest human understanding and sympathy.

REMARKS UPON THE TREATMENT OF PARESIS

CHARLES F. READ, M. D., STATE ALIENIST—CHICAGO

On June 30, 1923, there were 920 cases of general paralysis of the insane enrolled in the various state hospitals of Illinois. Of the 4770 patients admitted during the year of 1922-1923 for the first time to any institution, 560 were suffering from this same disease. Of the 1919 patients who died during this same year, 425 were cases of general paralysis. The average hospital life of patients admitted with this disease and who die in our state hospital is 1.11 years. Although over 500 patients were discharged as recovered, from the various state hospitals of Illinois during this same year, there was not one case of paresis—a shorter term for this same disease—among them.

The statistics of the state of Illinois are true for those of the United States in general, and even the enormous aggregate thus revealed does not account for all the ravages produced by this dread disease. Many patients doubtless die in private institutions or in the home before their conduct has become so bad as to necessitate hospitalization. Upon the average they are men in early middle life, men who have arrived at the most productive time of life, and have assumed the responsibilities of wife and children. In a recent study made by a social service worker in the East, it was found that the majority of the families of these patients became dependent upon charity or the earnings of the wife and mother who was forced to go to work when her husband went into the hospital.

Of the 560 patients admitted in 1922-1923 only 95 were women, thus leaving 465 men representing, at a valuation of $10,000 each, a loss to the state of Illinois of $4,650,000—aside from the cost of maintaining them in an institution for a year and a month, an expenditure which would run the total figure well up to $5,000,000.00!

This is a problem with which we have to deal in our state hospitals—a problem of the end results of syphilitic infections dating back from 10 to 20 years prior to the patients commitment as insane. It is said that

about 5 out of every 100 syphilitics develop locomotor ataxia or general paralysis of the insane. Obviously the rational way in which to deal with this problem is along the lines of prevention; first, the prevention of infection, and secondly, the prevention of the involvement of the central nervous system. But the prevention of venereal disease is a problem of social hygiene, while the prevention of an involvement of the central nervous system belongs for the most part to the syphilographers. What the state hospitals must endeavor to do is to make what repairs are possible to the damaged human mechanisms committed to our institutions for care and treatment.

By general paralysis of the insane, or paresis, we understand a disease of the central nervous system especially affecting the cortex of the brain itself, as differentiated from other syphilitic conditions involving the meningeal coverings of the brain or the walls of the blood vessels or the production of new growths, gummata, in connection with the meninges or blood vessels. Formerly it was thought that while syphilis had something to do with laying the general foundation for paralysis, other factors such as over work conditioned its development. This opinion, however, has of late years been revised by the discovery of Moore and Noughchi (in 1911) of the spirochaeta pallida in the brain substance of these patients. There is still, however, considerable discussion as to what determines this invasion of the brain. Some, notably Levaditi, contend that there are strains of this organism which are neurotrophic, having a predelection for nerve tissue, while others, dermatrophic in nature, by preference locate in other parts of the body and produce visceral syphilis. Certain experiments of Levaditi would seem to corroborate his views. As a matter of fact, it is quite commonly accepted that patients developing paresis have suffered few if any of the secondary and tertiary lesions common to ordinary syphilitic infection.

It has been well established by many observers that about 20 per cent of infected patients show early in the course of the disease some changes in the spinal fluid,

indicating an early involvement of the central nervous system, and it is probable that patients who later suffer from disease of the central nervous system are recruited from the ranks of those who suffer such early involvement; hence the necessity of examination of the spinal fluid in all cases of syphilis, with treatment especially directed to combating this invasion.

Unfortunately for our problem as to the treatment of paresis in state hospitals, the patients do not come to us until their behavior as the result of brain involvement has become so bad as to necessitate their separation from home and society. This means that, given an average duration of three years from the appearance of symptoms to the death of the patient, the state hospital has to deal with patients who are well along in the course of the disease, probably two years at least upon the average. Obviously considerable structural change has taken place and therapy is thus rendered so much the more difficult. The infected organism lies in the brain substance itself and is exceedingly difficult to reach with any drug known to us at the present time.

The history of the treatment of paresis is one of many therapeutic gestures and relatively small accomplishment. Fortunately for the paretic and unfortunately for the establishment of facts concerning cures, the disease is subject to spontaneous remissions in from eight to ten per cent of cases. Thus the patient who is apparently quite demented and about ready to die may without apparent cause or following an attack of erysipelas or other intercurrent infection, make a remarkable improvement which may last anywhere from a few months to many years, but inevitably the patient dies of his disease sooner or later—unless intercurrent disease carries him off meanwhile. For this reason statistics concerning the results of various treatments are unreliable unless observation is carried on over a long period of years, or a very high percentage of remissions are secured in a considerable group of treated cases.

It is unnecessary to recite the long history of the treatment of paresis here. Very naturally the discovery by Ehrlich of the arsenical known as salvarsan aroused

great hopes, and many favorable reports were received following the treatment of patients in various ways with this and allied drugs. Of late years, however, pessimism has again evidenced itself in numerous reports of considerable numbers of cases in which the results have been disappointing. This is notably true of various observers working in the state hospitals of New York State, where the number of patients benefitted, as quoted by Mills and Vaux (Archives Neurology and Psy. Vol. 9, No. 4) was only 15.9 per cent in 1920 and 13.8 per cent in 1921. Intra-spinal treatment was taken up with great enthusiasm at the time of the announcement of Swift and Ellis that favorable results had been obtained by the introduction into the subdural spaces of the patient's own blood serum following the intravenous injection of salvarsan. At the present time, however, but few clinicians are using this form of treatment in state hospital practice—and it must be understood that in this discussion we are limiting ourselves to such cases. Only a trace of arsenic can be found in the spinal fluid following intravenous injections of the arsenicals, and none whatever in the brain substance (animal experiments and investigation of cases dead from arsenical poisoning).

In 1917 Wagner-Jauregg of Vienna began to treat paresis with malarial infection upon the theory that the violent reactions thus obtained in some manner mobilize the defense resources of the organism, and reports a number of patients treated at that time to be still out of the hospital and doing well. At the present time reports upon this method of treatment claim a high percentage of remissions especially in the more incipient cases.

In May, 1923, Dr. Lorenz of Wisconsin with a group of workers (Journal of A. M. A. May 26th, 1923) reported as high as 50 per cent of institutional cases showing great improvement after treatment with tryparsamid, an arsenical derived from arsenic pent-oxide. Eighty per cent of the blood Wassermanns and thirty per cent of the spinal fluid Wassermanns became negative,—results heretofore not obtained with any type of treatment.

These findings were later confirmed by Moore of Johns Hopkins (Journal A. M. A., Feb. 16, 1924).

Following this inspiring report letters poured into our state institutions from anxious relatives inquiring if this new treatment could not be given to their patients, and accordingly in July, 1922, arrangements were made through the courtesy of Dr. Lorenz for a supply of this new arsenical, not yet upon the market, which can be given in very large doses—three grams each week intravenously, associated with a mercury salicylate. At the same time another group of similar patients was placed upon a modification of arsphenamine known as sulpharsphenamine. It is mainly with the results obtained with these two groups that this report has to do, although various other modes of therapy are being tried. At this same time 60 patients are under intensive treatment at the Elgin State Hospital with these and other remedies, notably new mercurials that can be given intravenously, a new arsenical allied to tryparsamid and a form of non specific treatment less dangerous than malarial infection.

We let the slides speak for themselves as to the exact results obtained, and summarize them in general as follows:

Remissions thus far secured in either group do not surpass the percentage that may be expected in cases treated in the usual manner with arsphenamine. The improvement in physical health in the tryparsamid group has been notable and many negative bloods have also been obtained, but no negative Wassermann in the spinal fluid as yet.

Several cases of apparent early optic atrophy (one or two of them very evident) have been found in both these treated groups, though the patients in the tryparsamid group were the only ones examined at the beginning of treatment.

Some of the sulpharsphenamine treated cases have also made marked improvements (one remission) but 25 per cent are worse than at the beginning of treatment, whereas none in the tryparsamid group have apparently deteriorated.

Though somewhat disappointed in the present results, the reporters realize that they have had to do with very unfavorable types for treatment and that it is really too early to draw worthwhile conclusions as to the results of this effort. In justice to the remedies employed another six months must elapse before publishing results in detail.

The reporters are grateful to Dr. Hinton, Superintendent of the Elgin State Hospital for his most cordial cooperation, to Dr. Hughes of Elgin for his painstaking examination of the fundi, and to Dr. Lorenz through whose courtesy a supply of tryparsamid has been received until quite recently.

The writer is continuing, in collaboration with Dr. Paskind of the Elgin State Hospital staff, this rather intensive piece of therapeutic research and hopes in another six months to have some very definite conclusions for publication.

THE RELATION OF ANIMAL DISEASES TO PUBLIC HEALTH

THOMAS G. HULL, CHIEF, DIAGNOSTIC LABORATORIES, ILLINOIS DEPARTMENT OF PUBLIC HEALTH, SPRINGFIELD

"Man is his own worst enemy" in the spread of communicable diseases, but the lower animals are a close second. It is only necessary to cite bubonic plague, a disease of rats, which carried off 25 percent of the world's population not so long ago and which is today costing the United States Government large sums of money in preventive measures. Another instance is sleeping sickness, a disease primarily of animals and transmitted by the tse-tse fly, which makes certain parts of Africa actually uninhabitable for either white man or native. Some prominence has been given this question lately through the offer of the Germans to give to the world a cure for sleeping sickness in return for certain territory.

But to get nearer home, take our own domestic cow. Tuberculosis is by far the most serious problem, ranging in extent from 2 to 3 per cent of the cattle in the southern part of Illinois to 50 per cent or more of the animals in the intensive dairying districts of the northern part of the state. The hogs that follow the cows, and the chickens that follow the hogs may also become infected with bovine tuberculosis and be incidental sources of danger. The chief source of danger is through milk to children. In surveys made some years ago in several large cities about 10 per cent of milk samples were found infected with tubercle bacilli, and this figure probably holds good today in the average small city of Illinois. Efficient and compulsory pasteurization has eliminated danger in the large cities. While 25 per cent of tubercular children formerly were infected with the bovine type of the disease, recently bone and gland tuberculosis (evidence of the bovine infection) have been rare occurrences in cities like Chicago. Dr. Lorenz on his last visit to this country cried, "Where is your bone tuberculosis?"

Two other diseases, anthrax and foot and mouth disease, may be spread not only by cattle, but also by the other domestic animals which are subject to infection. There occurred during the calender year 1922 in the United States 89 cases of human anthrax, of which Illinois had four. The disease is well under control, although present in various parts of the country. Foot and mouth disease is rather rare in man, due principally to the immediate destruction of infected animals. Milk is a possible source of danger, but proper pasteurization will prevent infection.

Contagious abortion among cattle is very prevalent, but its relation to human welfare is not yet settled. Huddleson has shown the presence of abortion bacilli in milk from infected cattle, and Park and others have shown as high as 25 per cent of individuals giving agglutination reactions to this organism. In several states the problem is considered of public health importance and tests for the disease in cattle are performed by the laboratory of the State Board of Health. The writer at one time observed a herd of cattle badly infected with contagious abortion where the wives of three successive herdsman gave premature births to children. Pasteurization of milk is a proper safeguard to the public.

Trichiniasis, primarily a disease of hogs, has played a considerable part in the world's history. The old Jewish law against eating pork was in all probability the result of havoc wrought by this disease. Great epidemics in Europe have been caused by the parasite, trichinella spiralis, and some forty years ago it caused international complications between this country and Germany, with the result that American pork was barred from German markets. The danger from eating raw pork is today common knowledge, yet from 0.5 per cent to 2 per cent of the population of civilized countries show trichina embryos at post mortem examinations.

Glanders, very common in horses, is rather rare in man. The two classes of persons likely to be infected are hostlers and laboratory workers. Recently a case in Illinois was drawn to the attention of the writer through laboratory examinations. The disease was not suspected

previous to this time. Often the symptoms are very obscure, and it is possible many more cases may occur than are recognized.

Rabies is spread usually by our good friend, the dog, though all other animals are susceptible and if infected are sources of danger. The disease for centuries was the dread of all peoples, in some communities the unfortunate person bitten by an infuriated animal being put to death immediately. Not till fifty years ago did Pasteur discover a preventative which has greatly reduced the mortality. In 1922, 50 deaths were reported in the United States. At the present time there amounts to what is almost an epidemic of rabies among dogs in the southern part of Illinois.

Of all useless animals on earth, the rat is the most detestable. As a marauder he is bad enough, as a murderer he excels. Reference has already been made to bubonic plague, which has swept the world in three great pandemics. The first authentic epidemic originated in 542 A. D. in Pelusium, Egypt. It spread by trade routes over the then known world, till at its height the morality was 5,000 persons a day and rose to 10,000 persons some days. According to Procopius, a witness of the epidemic, "It spared neither island nor cave nor mountain top where man dwelt—. Many houses were left empty and it came to pass that many for want of relatives and servants were left unburied for several days. At that time it was hard to find any one at business in Byzantium. Most people who met in the streets were bearing a corpse. All business had ceased, all craftsmen had deserted their crafts." The second epidemic, known in history as the Black Death, originated in Mesopotamia about the middle of the eleventh century. Again the disease spread by trade routes over the entire known world, carrying off 25,000,000 people, or one-fourth the population of Europe. The third epidemic had its origin in China in 1871, coming to the ports of Europe and America. Due to advancement of the sanitary sciences and their strict application in war upon rats and fleas, the world epidemic never reached beyond isolated cases at seaports in Europe and America. The disease is of especial importance to Illi-

nois because of the water ways from the two coasts, and will be of increasing importance as these waterways are improved for ocean-going vessels.

Of lesser importance are infectious jaundice and rat bite fever. Rats in many cities in the United States have been shown to harbor the Spirocheta icterohemorrhagiae, causing infectious jaundice in man. In Illinois several epidemics have been reported. Rat bite fever is less prevalent in this country than in other parts of the world, though some cases have occurred here. The causative agent is Spirocheta morsus muris harbored by rats. Very recently the United States Public Health Service has been making an extended investigation of tularemia, a disease of rats transmitted by the rat flea to man. Man seems very susceptible to the disease. The bacteriologists in Washington who were working with the causative agent, Bact. tularense, one after another became infected till everyone connected with the problem had had the disease. The Lister Institute in London then requested a culture of this virulent organism, which was sent, together with a warning that great care must be used in handling it. In spite of this warning, word was received two months later that the bacteriologist working on tularemia had contracted the disease. Added interest was lent to the subject when many rabbits for sale in Washington markets were found infected with tularemia.

Goats are subject to a disease known as malta fever, which may be transmitted to man through goat milk. In Texas considerable trouble has been caused in this manner. Guinea pigs usually are harmless little creatures, but recently an epidemic of "guinea pig plague" was reported in man. The infection was spread to bakeries by rats.

The domestic fowl is especially subject to a disease known as "white diarrhea". The writer some years ago found the disease especially fatal to young rabbits, young kittens and young guinea pigs. The eggs from infected hens contain large numbers of the organisms,—Bact. pullorum,—which are not destroyed by usual methods of cooking eggs. The relationship of the disease to man is problematical, but there is little doubt that a severe

gastro-intestinal upset if nothing worse might be caused by a young child eating infected eggs. This disease is very prevalent in poultry in Illinois.

Another problem that keeps recurring is the relation of paralized animals to poliomyelitis. In Illinois a few years ago the writer had the opportunity to study several outbreaks of paralysis among animals which epidemiologically were closely related to poliomyelitis among children. Laboratory studies however were negative. The animals included in these studies were colts, hogs, and chickens.

Brief mention should be made of intestinal parasites. Tenia saginata, the beef tapeworm, Tenia solium, the pork tapeworm, and Dibothriocephalus latus, the fish tapeworm, all infect man. Belascaris mystax is a common parasite of the dog and cat and hence found in children.

Some of the arthropods are subject to diseases quite fatal to man. Among these are ticks, transmitting relapsing fever and rocky-mountain spotted fever, lice which spread typhus fever, mosquitoes whose bite causes malaria, yellow fever, dengue and filaria, and the flies especially in regard to sleeping sickness.

This paper must not be closed without including an animal disease which is not fatal to man, but which has actually been the means of saving a countless number of human lives. This is cowpox, infection with which will prevent the fatal smallpox in human beings.

MOSQUITO AND MALARIA CONTROL IN ILLINOIS

HARRY F. FERGUSON, CHIEF SANITARY ENGINEER, DIVISION OF SANITARY ENGINEERING, STATE DEPARTMENT OF PUBLIC HEALTH, SPRINGFIELD

All counties in Illinois suffer more or less from malaria and mosquitoes. In the northern and central portions of the State where much of the land has been fairly well drained for agricultural and other purposes, malaria is much less prevalent than in the southern counties, and the mosquito pest has been greatly reduced except in certain special areas. The death rates from malaria are especially high in the southern counties, and that portion of the State has been termed the "malaria belt of Illinois".

The accompanying map of Illinois shows the malaria death rates by counties for the fiscal years from June 1, 1919, to June 30, 1922. When it is considered that for each death from malaria there are approximately 300 cases of that disease, the case rate in the southern counties will be seen to be quite high. Moreover, many deaths are caused by illnesses which would not have been incurred if the individuals had not previously been infected by malaria and left in a weakened physical condition. This is especially true of children, for if children are infected by malaria in their growing years their growth and vitality are probably greatly reduced.

As an example of the economic loss from malaria, reference may be made to Jackson County. Vital statistics show that there are occurring in Jackson County between 2,700 and 3,000 cases of malaria a year. Assuming that the economic loss per case is $100, which would be a conservative figure, and include the cost of medicine, doctor bills, and loss in productive earnings, the economic loss to Jackson County is over $250,000 yearly. Thus that county and other similar counties could well afford to spend considerable sums yearly until mosquito-breeding places have been eliminated.

Drainage work that has been going on for many years in Illinois to reclaim land or make it more productive for

Malaria death rates in counties in Illinois.

agricultural purposes has resulted in a great decrease in the amount of malaria among the inhabitants because malaria is spread only by the bite of a certain type of mosquito, and this mosquito, like all types of mosquitoes, can breed only when stagnant water is available in which to lay eggs and in which the wiggler stage of the mosquito's life can be passed. The economic saving from decreased sickness and deaths from malaria, and also other diseases which may have attacked individuals when in a weakened condition from malaria, is not generally taken into consideration in drainage projects, but it really should be included as a benefit as well as the increased productiveness of the land. In some instances the economic saving from decreased illness alone has been undoubtedly far in excess of the cost of the complete drainage work.

In 1916 the chief sanitary engineer of the State Department of Health called attention in an article in "Health News" (the monthly publication of the department) to the heavy economic losses caused by malaria in Illinois, especially in the southern portion. No systematic malaria-prevention work by mosquito eradication was undertaken in Illinois, however, until 1922, but in the meantime the matter was given consideration by the Southern Illinois Medical Society, and as the result of a resolution of that society, studies of mosquito-breeding places and the types of mosquitoes prevalent in some southern Illinois communities were made by entomologists of the State Natural History Survey.

With the 1916 report of the State sanitary engineer, the resolution of the Southern Illinois Medical Society, and the studies of the State Natural History Survey entomologist as a background, the question of systematic malaria-mosquito eradication was presented on several different occasions, as opportunity offered, by the State Division of Sanitary Engineering to the city officials and interested civic organizations and citizens at Carbondale. It was considered that Carbondale presented, for various reasons, the best place to demonstrate what could be done in the way of mosquito eradication and that cities would benefit by such work.

As a result the Lion's Club of Carbondale went on record on January 27, 1922, guaranteeing to raise a fund of $2,000 in order to carry on systematic malaria-mosquito control during 1922. The International Health Board had previously tentatively agreed to furnish $1,000 and the Illinois Central Railroad had given favorable consideration to the draining of many acres of swamp land adjoining the city on the north. The State Department of Public Health had agreed to provide the services of a sanitary engineer to supervise the work, and the assistance of the State Natural History Survey and the U. S. Public Health Service were also assured.

Proposed and recommended by the State Department of Public Health, sponsored by the Lion's Club of Carbondale and receiving financial assistance from that club, the International Health Board, and the Illinois Central Railroad, and directed by the Sanitary Engineering Division of the State Department of Public Health, Carbondale carried on systematic mosquito-control work for the season of 1922, and for the first time in the history of the city enjoyed practically complete relief from the pestiferous insects. The results from the standpoint of reduction in malaria cases were equally gratifying. Vital statistics and house-to-house canvasses had shown that prior to 1922 the city suffered an average of over 250 cases of malaria a year (267 during 1921). Following the close of the mosquito-control work for 1922 it was found by a house-to-house canvass that only 19 cases of malaria had occurred during that year in the entire city. It is quite probable that some of those few cases were recurrent cases or may have received their infections elsewhere.

The results were so satisfactory to the city officials and civic organizations that had participated in the work, and the economic saving to the community was so apparent that arrangements were made to carry on similar control work during 1923. During 1923 the city was again practically free from mosquitoes and only 11 cases of malaria were found by a house-to-house canvass. With these two successful seasons' work as a practical example of what can be done, the city is making arrange-

ments to carry on mosquito control during 1924 and provision will probably be made in the city budget for such work each year in the future. The work has been found to save lives, to eliminate the pestiferous mosquito, and to make a considerable economic saving to the community. The cost of the work at Carbondale for 1922, not including the supervision by a State sanitary engineer, was about $2,600. At least 250 cases of malaria were prevented, and considering the economic loss as $100 per case, the net economic saving to the community for the mosquito-control work was over $20,000. The cost for the second season's work (1923) was only about $800 and thus the economic saving was even greater.

Following the example set by Carbondale, the city of Belleville undertook complete malaria-mosquito control during 1923. The work was assured by the interest and financial assistance of the local Lion's and Rotary Clubs, the Board of Trade, and the city officials. Financial assistance was also given by the International Health Board and a State sanitary engineer directed the work. From vital statistics for previous years and a house-to-house canvass at the beginning of the control season of 1923 and another canvass at the end of the year, it was found that the mosquito-control work reduced the malaria in the city to about one-eighth of what had existed in previous years.

Malaria had not been quite as prevalent in Belleville as in Carbondale, but nevertheless the control work resulted in preventing at least 110 cases and made the city practically free from the bothersome mosquito. The season's control work cost $3,020 and from the record of the number of malaria cases during previous years and during the control year it is conservatively estimated that the net economic saving to the community was over $8,000. The cost of control work for future years will be less because of some permanent work done during the first year, and thus the economic saving will be correspondingly greater.

The work at Belleville was locally considered very beneficial and profitable and provision is being made in the city budget, with some additional financial assistance

by interested civic organizations, for the 1924 season's work and probably for future years the city may finance the entire work.

Malaria and mosquito surveys have been made by State sanitary engineers at Herrin and Pekin in response to requests from interested citizens and organizations and at a few other Illinois communities. Herrin will undertake systematic control during 1924 the same as Carbondale and Belleville. The work at Pekin may be delayed until 1925 because of certain local conditions.

It is unwise to spend money for mosquito control unless the control is planned in a systematic manner and will extend over a suitable area, and such work can not be really successful unless a community is thoroughly interested and the individual citizens cooperate. The State Department of Public Health is desirous of assisting communities in malaria and mosquito control, and will arrange to have a survey made of malaria and mosquito conditions in any community and direct the control work wherever a community is sufficiently interested.

Before discussing the control measures used at Carbondale and Belleville it may be well to review the life history of the mosquito, the manner in which malaria is spread by one type of mosquito, and then outline the various methods that can be used to eradicate malaria and to prevent mosquito breeding. Because many of the persons attending this meeting are undoubtedly somewhat familiar with the life history of the mosquito the matter will be presented very briefly.

Two types of mosquitoes may be mentioned: the Anopheles, the female of which can spread malaria, and the Culex or ordinary pestiferous mosquito. The life cycle of a mosquito is divided into four stages, the first three of which are entirely dependent upon water for their continuance. The entire cycle from the egg to the adult requires from 7 to 10 days, depending upon climatic conditions and water temperature.

The mosquito lays her eggs on water. The eggs of the Anopheles are laid singly, as distinguished from the eggs of the ordinary Culex which are laid in rafts, each raft containing from 200 to 300 eggs. In two or three

days' time, the eggs hatch into the larvae or "wigglers". Anopheles wigglers swim horizontally on the surface of the water and when disturbed, dart laterally. Culex

Patterns assumed by Anopheles ova. (After Deaderick.)

A raft of culex ova. (After Deadrick.)

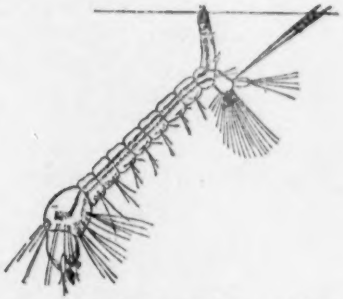
Larva of Anopheles mosquito. (Castellain and Chalmers. Modified after Howard.)

1

2

3

Pupae; 1, Culex; 2, Anopheles; 3, Aedes colapus. (After Howard.)



Larva of a culex mosquito. (After Howard.)

1 2 3

Resting posture of mosquitoes; 1 and 2, anopholes; 3, culex pipiens. (After Sambon.)

Fig. 2. Life cycle of Anopheles and Culex mosquitoes.

wigglers hang head down, with their tails protruding through the surface, their bodies at an angle of about 60 degrees with the surface, and when disturbed, dart downward. Although living in the water and feeding on small organisms and plant life, the wigglers are at all

times true air breathers, securing their supply of air through respiratory siphons located on their tails. In two or three days, the wigglers or larvae develop into pupae. Both types of pupae resemble very closely the figure of the comma (,). In two or three days the shell of the pupa splits and the adult mosquito emerges.

The Anopheles mosquito may be distinguished from other types of mosquitoes by the definite markings on the wings and by the position it assumes when resting or feeding. When resting or feeding its proboscis and body are in the same line, and at an angle from 45 to 90 degrees with the surface upon which it is resting. The ordinary Culex mosquito has transparent wings and when resting, keeps its body parallel with the surface.

The life habits of the two types of mosquitoes are different in a great many respects. The Anopheles apparently has the better taste and will not breed abundantly in sewage-polluted water. Anopheles crucians breed most abundantly in swamps and fresh marshes; Anopheles punctipennis prefer slowly moving streams, while Anopheles quadrimaculatus choose woodland pools and the shallow portions of lakes and ponds. The Anopheles mosquito very seldom bites in the daytime and its song is much quieter and less annoying than that of other types. It does most of its work between the hours of sunset and sunrise. The Culex mosquito is very annoying both as to song and bite, and will make its attacks in the daytime as well as at night.

Only Anopheles mosquitoes, and only the females of that species, can spread malaria. In the "dark ages" of malaria it was commonly believed that the disease was caused by breathing or contact with air in low places or which had passed over swamps or stagnant ponds, especially at nighttime. Whence the name malaria from two Latin words, "mal" meaning bad and "aria" meaning air. There was a grain of truth to this unscientific but popular understanding of the cause of malaria, for it is true that the Anopheles mosquito that can spread malaria breeds in swamps and stagnant waters and flies almost entirely after dusk or dark.

To spread malaria, the female Anopheles must first bite and suck the blood of a person infected with the disease. Then after the parasites of the disease have undergone certain changes while in the body of the mosquito and have passed through its stomach walls and reached its salivary glands, the mosquito can spread malaria to the persons it thereafter bites.

Malaria is caused by the animal parasites that are injected into the blood stream by the biting mosquito. The chills and fever accompanying the disease are the result of the multiplication of these parasites and the simultaneous liberation of millions of daughter parasites from their parents.

Malaria control may be conducted along three general lines, any one or combination of which will meet with a fair measure of success: (1) by the prompt and proper medical treatment of infected persons so as to eliminate sources of infection for the mosquitoes; (2) by screening houses and the sick bed and otherwise preventing the mosquito from becoming infected, or an infected mosquito reaching well persons; and (3) by eradicating the mosquito primarily through the destruction or proper treatment of mosquito-breeding places. The eradication of mosquitoes is the most effective, and besides preventing malaria gives relief from annoyance. It is a problem for the sanitary and drainage engineers.

The fight against the mosquito must be directed against its water stages, particularly against the wigglers. The mosquito must be killed while in the process of developing and before it takes the wing. All types of mosquitoes invariably make use of all the natural protection afforded for breeding. Along streams the wigglers may be found close to the shore, among the protecting grass and weeds, in the vicinity of drifts, close to logs, among fallen leaves and other accumulations of a like character. The same is true of ponds and pools, the wigglers always being found in the shallow portions among the marginal growths that furnish such excellent protection.

Drainage as an antimosquito measure is the most effective. To remove the water is to eliminate the breed-

ing place. Drainage of swamps, marshes and ponds can be effected by the construction of open ditches or tile drains, preferably the latter because of their permanency. In some cases ponds can be drained by vertical drainage. Old ditches with numerous potholes should be regraded and cleared in order to drain the potholes and keep the grass and weeds away from the water. A small trench cut in the bed of an old ditch or stream will confine the dry-weather flow and do much to keep the grass and vegetation from encroaching. A tile laid in the bed of an old ditch will remove the trouble entirely. Small depressions and pools can sometimes be more economically filled than drained.

The work of clearing as an antimosquito measure can not be over-emphasized. The work appears of little consequence perhaps, yet in many instances at least 90 per cent of the breeding can be destroyed by this work alone. If stagnation of the water is prevented and the marginal vegetation removed, there can be but little breeding.

Places that can not be drained or filled in should be treated in some manner. Oil is the most efficient as well as the cheapest larvicide known at the present time. In some cases lime, hog dip, niter cake, and other compounds can be used to good advantage. The oil, in addition to creating a thin film over the water surface through which the wiggler can not penetrate its breathing tube, acts as a poison and kills the wiggler much more quickly than by suffocation. Kerosene is effective and easily spread, but evaporates comparatively rapidly. Kerosene mixed in the proportion of about 4 to 1 with crude oil makes the best mixture. The oil may be applied by sprinkling oil-soaked sawdust along the edges of lakes or streams, by oil drips, swabs, or sprayers. The sprayer is considered the most effective implement, the Panama knapsack sprayer being the one more widely recommended. Because the oil evaporates or after a while separates so as not to form a continuous film over the surface of the water, oiling must be done at regular intervals of about 7 days.

Paris green is strictly a malarial mosquito larvicide. When mixed in the proportions of about 2 parts Paris

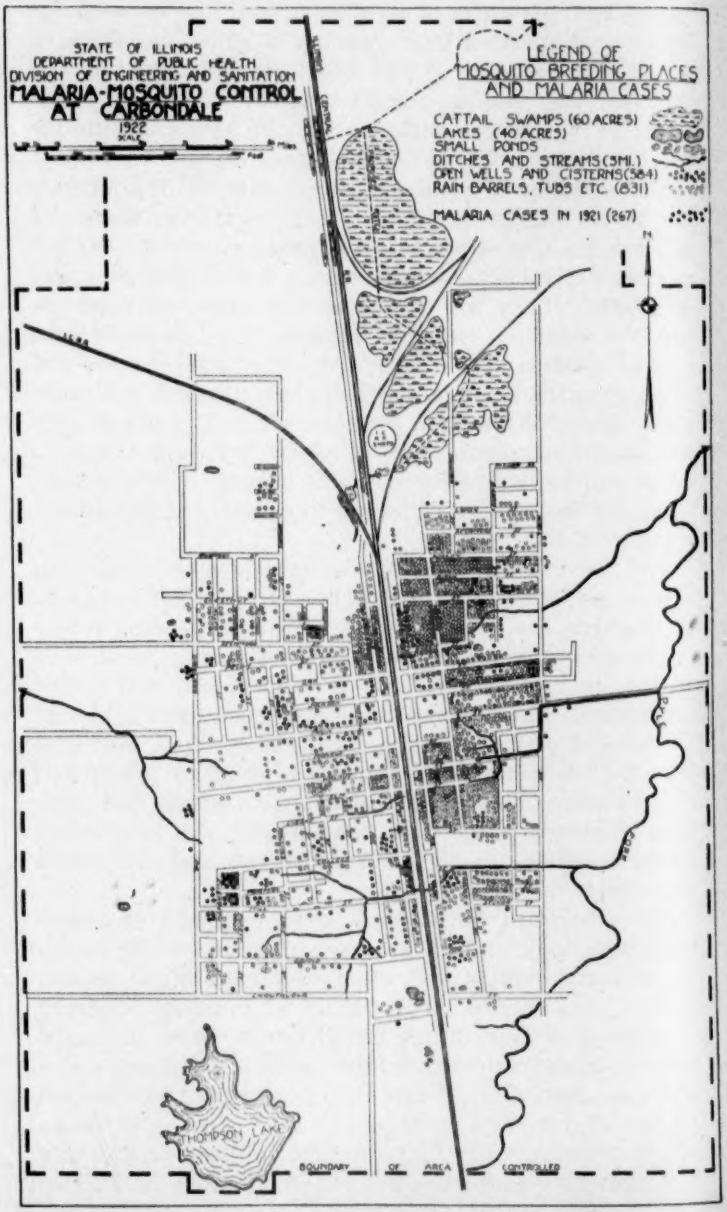
The vicious circle. Mosquitoes breed in water; they become infected from sucking the blood of malaria victims; they then spread malaria by biting well persons; and thus the vicious circle continues. To break the circle eradicate the mosquito.

green and 100 parts of road dust, and strewn with the wind over marshes and swamps, a great reduction in anopheline breeding can be noted. This is explained by the fact that the Anopheles wigglers or larvae, swimming on the water surface, come in contact with the arsenic flakes, while the other larvae do not.

The stocking of ponds and lakes with the top minnow known as Gambusia affinis, is an important means of control, for these little fishes swimming near the surface of the water and near the banks devour the mosquito wigglers. If the fish are present in sufficient numbers, namely, about one minnow for each yard of shore line, and no protection is afforded the wigglers by grass and other growths through which the minnows can not penetrate they will establish complete control. Rain barrels and other man-maintained mosquito-breeding places in cities can be controlled by rigid house-to-house inspections, by the passing of mosquito ordinances and educational measures.

For the control work at Carbondale a working map was prepared showing all ditches, streams, lakes, ponds, depressions, and other possible mosquito-breeding places in the area to be controlled. The area comprised all land within the city and one mile in each direction from the city limits. The mosquito-breeding places included about 60 acres of cat-tail swamps on the north side, a 40-acre lake on the south side, a number of small ponds and about 6 miles of ditches and streams, all within mosquito-flight distance of the city. The trouble was augmented by an enormous number of rain barrels and open wells and cisterns.

The control of the natural breeding places was comparatively easy, and the greatest difficulty was the breeding in rain barrels and other man-maintained places. Control was carried on by means of drainage, clearing of existing ditches, oiling, use of top minnows in ponds, open wells and cisterns, and the scattering of Paris green and road dust. The Illinois Central Railroad constructed by use of dynamite 9,000 feet of ditch for the drainage of the swamps. The first estimate of cost for draining and clearing the swamps was $8,000, of which $2,500 was



Malaria-mosquito control area at Carbondale, 1922.

for the ditch to be constructed by hand labor. By use of dynamite the ditch was actually constructed for about $1,200.

The 40-acre lake on the south side was abundant with cat-tail growth and pond lilies in a number of small bays, and there was also a fine growth of grass around the edge of the lake, making it an ideal breeding place for mosquitoes. The water level in the lake was dropped 18 inches by cutting the outlet wall, and a great reduction in breeding was at once apparent. The bays were cleared of the cat-tails and pond lilies, and portions of the surface and the edges oiled throughout the season. A careful examination in September failed to find any breeding, when in May before the work started as many as 200 larvae could be secured in a single dip with a small dipper. All ditches and streams in the area were carefully regraded, cleared and kept in a proper condition throughout the season for oiling. All ditches and other collections of water in the area were oiled once each week. Frequent inspections showed that almost perfect control was established on natural breeding places.

The most troublesome part of the campaign was the control of rain barrels and other man-maintained breeding places. In June, out of 664 open wells and cisterns, breeding was found in 391, and 584 were immediately stocked with Gambusia. A later inspection of 60 wells and cisterns showed that the fish were performing their duties well, only two cisterns being found breeding, and the fish had apparently been removed from these. The control of rain barrels and tubs was accomplished by regular house-to-house inspections. In June the first inspection showed 1,030 containers, 831 being rain barrels and tubs which were found breeding mosquitoes. The second inspection in June caught 296 containers breeding, the third inspection 154, and the fourth inspection 206. For the fifth inspection every container holding water in the city was oiled. The sixth inspection caught 19 containers breeding, the seventh 7, and the eighth 11. By the height of the mosquito season, almost perfect control had been established.

The control work at Belleville was somewhat similar to that at Carbondale. The greatest trouble at Belleville was a sewage-polluted stream flowing through the city. The city is now planning a sewerage improvement which will remove the pollution from that stream and thus greatly reduce Culex mosquito breeding and also make possible the clearing and maintaining of the stream in such condition as to promote the development of top minnows, and thus the control of all mosquito breeding.

In addition to the mosquito-control work in southern Illinois carried on under the supervision of the Division of Sanitary Engineering of the State Department of Public Health, mention should be made of the mosquito-control work carried on during 1922 along DesPlaines River, within the limits of the Chicago Sanitary District. At the request of persons residing in some of the communities in the towns along that river, a preliminary inspection was made of mosquito-breeding conditions and it was decided that the greatest source of the trouble was the sewage-polluted DesPlaines River. Because of the pollution carried by that river the mosquitoes breeding in it were Culex and thus not malaria carriers.

Mosquitoes were found to be breeding in the river by the millions, and the interested parties were advised that satisfactory control would not be possible unless the various adjoining communities joined together in a systematic control program. At this time the Chicago Sanitary District agreed to undertake mosquito-control work in that area, and although the mosquito-breeding season had already started before the field-control work could be started, Joseph F. Base, engineer engaged by the Sanitary District to supervise the work, carried on a very successful season's control and decreased the mosquito nuisance in that area to a very small fraction of what had prevailed during the previous years. The control work was not continued by the Sanitary District during 1923, but some work was done by the communities and it is understood that the Sanitary District will possibly carry on the work during 1924.

The mosquito-and-malaria-control work in Illinois has been merely an application of the scientific knowledge

Ditch before and after being cleared so it could be oiled.

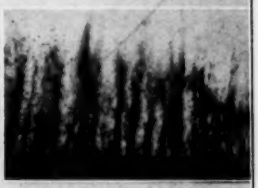
Stagnant sewage-polluted ditch before being cleared. A prolific breeding place for mosquitoes.

Oiling a cleared ditch to kill mosquito wigglers.

Malaria-mosquito control at Carbondale, 1922.

One portion of Thompson Lake covered with lilies and another portion after clearing out lilies and cat-tails. By clearing out such vegetable growths fishes, especially top minnows, have access to and devour the mosquito wigglers, thus preventing development of adult mosquitoes.

Placing dynamite in path cut through cat-tail swamp for blasting a drainage ditch.



Blasting 700 feet of ditch with dynamite at one shot.

About 60 acres of cat-tail swamps near Illinois Central Railroad shops at north edge of city were prolific breeding places for mosquitoes that spread malaria among persons working in shops or living in the northern part of the city.

Close-up view of path cut through part of cat-tail swamp before blasting ditch.

Ditch immediately after blast filling with water.

Ditch made with dynamite; no hand clearing yet done.

Interested spectators of ditch just blasted.

Catching top minnows (Gambusia affinis) from ditch blasted through cat-tail swamp for use in rain barrels, cisterns, etc.

Malaria-mosquito control at Carbondale, 1922.

that has been developed by entomologists, biologists, physicians, sanitary engineers, and other scientists, and many cities in Illinois would do well to make use of similar knowledge. Mosquito-control work, when properly planned and carried out, not only prevents sickness and deaths from malaria, but eliminates the mosquito pest and actually benefits a community financially by reducing the large economic loss suffered because of sickness and deaths from malaria. The mosquito-control work already done is an instance of what really can be accomplished by the proper application of scientific knowledge, and the malaria death-rate map of Illinois shows the large amount of work remaining to be done and only awaiting the realization of the communities and counties of the benefits to be derived from such work.

PRACTICAL VALUE OF FULL TIME HEALTH OFFICERS

E. W. Weis, M. D., Director, Hygienic Institute, LaSalle

It seems superfluous to attempt to advance any arguments in favor of a proposition that is obvious to any one that will give it a moment's attention. Unfortunately, however, people are so constituted that they will not give serious consideration to the apparent, simple things of life whose results stand for everything that we would like in the way of better health, increased longevity, greater physical efficiency, and more happiness. Probably the reason for the great indifference of the people at large is due to the fact that the ordinary individual depends upon the State or the Municipality to provide whatever protection is necessary. While this is now true, in the main due to our more thorough knowledge of the cause of deteriorating conditions, it has become a question of individual as well as State responsibility. The individual, however, does not like to sacrifice his convenience for the public good; therefore the Public to defend itself must resort to preventive measures, making observance of well known rules and regulations compulsory, and for the better carrying out of these principles men trained specifically to this work emphasize the practical value of a full-time health officer.

That this condition has been appreciated is proven by the fact that many colleges now give special courses and training in public health work, many societies have been organized whose deliberations are only on this line. Many journals now devote all of their pages to preventive medicine and to public health endeavors. Yet with all of this we are woefully lacking in sufficient good material to present the message properly. Public health service for years and years has been dealt with in a haphazard sort of fashion, and because of the fact that we are not daily threatened by an epidemic that takes a large toll of lives, we become indifferent, and the custom has grown to employ some man with a slight knowledge to carry on this work. This means the part-time man.

I know whereof I speak, as at one time I enjoyed this position at the munificent salary of $300 per annum, and now I know that I was overpaid. I am safe in saying right now that the same is the case anywhere where a part-time man is employed; in other words, there is no value under these conditions. Owing to the fact of remarkable discoveries being made of the causes of disease, especially of communicable diseases, and also owing to the fact that the laity reads and digests this knowledge, a demand has been created for Directors who will devote their entire time and energies in this field; hence the full-time man, and just now physicians are beginning to appreciate this work because more men are entering this field than ever before.

Physicians have been very slow to do health work; first, because the compensation has been very small; second, the prospect of advancement beyond a certain point has also been small; but we are beginning to realize that a good salary regularly received is worth more than the general compensation of an uncertain practice. Another factor may enter into this problem and that is the absence of mathematical demonstration of the results, nor have we patience enough to allow a period of years to elapse to prove the benefits received. As an example, and this has occurred often, a case of infectious disease arrives in a town, is laxly controlled and fifty other cases result. In a neighboring city the same original case arrives, is thoroughly controlled and no other case results. Is there a benefit credited or claimed? Now this is going on all the time.

Dr. McCullough of Ontario in an address recently read before the American Public Health Association says, "Considering the situation at the present time, the conclusion has been reached that our greatest need is a competent full-time directing head of a health department with an efficient organization, whether it be in the state, the county or the municipality. Public health is a large business, and some of us at least may be of the opinion that the advancement of public health is one of the most important if not the most important business of the state". According to the figures collected by Dr. Fer-

rell in 1914, there were but three full-time health officers in the United States. At the present time there are close to 250, and the figure is being added to rather rapidly. In Illinois the County Health Officer Bill failed of passage in the last Legislature. In spite of that we now have two, Morgan and Jacksonville combined and Cook County. There are only three full-time municipal health officers, exclusive of Chicago, in the state. These figures taken collectively prove that the sentiment in favor of full-time men is being rapidly appreciated.

The trend of medicine today is toward prevention, and it depends upon the trained hygienist and sanitarian to spread the knowledge that is necessary in this preventive work. What was formerly considered the ravages of time we now know are the ravages of bacteria and an unphysiological manner of living. With the adoption of safety measures, thus avoiding accidental conditions including those producing malignancy, it would be interesting to note just what the limit of life would be. To this particular phase of work the full-time man should devote considerable attention. Seven years ago I devoted considerable time to training trees with results that were remarkably gratifying, and we all know what Burbank has done both by careful selection and cultivation. As the secret of our education is to begin with the young, it is evident that the Hygienist and the Sanitarian should be ones who can impress upon impressionable minds the lessons of prevention and proper methods of living. A full-time man proves his value in proportion to his knowledge and application of it to the oncoming generation. The part-time man has neither the ability nor the inclination and certainly not the time if he is in active practice. Therefore he is not to be considered in this connection at all.

There are two problems, and very serious ones, in the appointment of full-time health officers; one is the tenure of office and the other is his political associations. It is apparent that any full-time man who must rely on political influence to continue in office is not the man who should be employed. It is unfortunate that at the present time most of the appointments are political, and as Ruhland of Milwaukee has observed, "Under these circumstances it is not difficult to see that those who are

asked to take the responsibility of public health service will treat that appointment somewhat as a side issue and not as *the* issue."

The great objection to the employment of full-time men has been the supposed inability to pay a requisite salary. This objection is overcome in the State of Illinois and in several other States by the adoption of the law wherein two or more towns can join together and form a public health district and levy a small tax for the maintenance of the health department. If this is properly presented there should be very little difficulty in securing public health departments in any number of communities, for the benefits conferred are far greater than can be had by any other investment. To nullify as much as possible political influence, the law of Illinois provides that appointments should be made from a list of eligibles from the State Department of Public Health, and this list is made up by a competitive examination.

The law that I refer to was caused to be placed upon our statute books by the late Mr. F. W. Matthiessen of LaSalle, a man of remarkable vision and fortunately associated with it the ability to determine its expediency. He endowed the Hygienic Institute for LaSalle, Peru and Oglesby with sufficient funds, the income of which pays the necessary expenses. The Hygienic Institute is a corporate body operating solely for the benefit in public health service for the three cities mentioned. The Institute employs a Director who is Health Commissioner of each city and a member of the board of health of each respective city. The Hygienic Institute is controlled by a Board of five Trustees and is perpetual in character. Besides the Director it employs necessary assistant Health Commissioners, Bacteriologist and Chemist, three school Nurses and an Infant Welfare Nurse, a Veterinary for inspection of dairies, Stenographer and assistant Technician, and owns and operates one of the finest Isolation Hospitals for contagious diseases. All of these at its own expense, and the price is not prohibitive to any community of our size. Our records prove that our morbidity and our mortality and our longevity are of a better percentage than communities who do not operate with a full-time health officer.

SOME COMMENTS ON THE PHYSICAL FINDINGS IN HIGH SCHOOL GRADUATES

J. Howard Beard, M. D., University Health Officer, Urbana

The generalizations made herewith are based directly upon 2955 medical examinations of high school graduates made in September, 1922, of which 885 were of women and 2070 were of men. They are further supported by similar approximate findings in a total of 12,000 medical records of high school graduates, of which 9000 are of men and 3000 of women. As one group of 26 physicians and 18 specialists and dentists assisted in examining the men, and another of 11 physicians and 4 specialists assisted in examining the women, the total defects considered represent a composite opinion rather than that of one individual with a preconception or a fixed idea.

The most important deduction, in my judgment, to be drawn from the findings of the medical examination of high school graduates is that physically, mentally, and morally, they are unsurpassed by any group of similar age of which there is record for comparison. It should be pointed out at the outset that a large proportion of the mechanical defects noted are minor and are not, in reality, a serious handicap in civil life. Impairments of the special sense organs and of the teeth are to such a large degree correctible, as, in the vast majority of cases, not to interfere markedly with effective living.

GENERAL DEVELOPMENT

Slightly more than one-half of the high school graduates examined in 1922 received a classification of good in their physical development at the time of their physical examination. About one-third were recorded as fair, 3.2% of excellent development, and 5.2% of poor development.

The relative general development of men and of women differs but little. A slightly larger per cent of the men are classified as good; a somewhat greater per cent of women than of men, as fair. This difference in physique of men and of women may be influenced, in a

measure, by the opinion of different groups of examiners, but it has tended to become less each year. This decrease in the variation in classification in the physical development of men and women parallels the progress of physical education in the grammar and in the high schools.

The general nutrition of the group is very close to average, but with a slight tendency towards thinness. Men are more apt to be average than women, who seem to show a slightly greater tendency to approach the extremes of either slenderness or obesity. The finding of a greater tendency of women than of men toward either overweight or underweight when registered is consistent with a similar finding of girls and boys from nine to sixteen years inclusive. The causes of underweight considered broadly may be classified as those of race and those of malnutrition. There is a greater general tendency for high school graduates from the city to be underweight than from the rural districts. This is chiefly due to the fact that such small races as southern Europeans and Polish Jews tend to locate in the towns rather than in the country. Shortness of stature is largely independent of environment. It is a characteristic of the above races, and in this country has a geographical distribution similar to them.

Unhealthy environment, bad habits of eating and exercise, and physical handicaps are productive of underdevelopment. Defective vision, deafness, large tonsils, adenoids, nasal obstruction and communicable disease are also preventives and deterrents of growth.

It is the general observation, however, that high school graduates presenting themselves for physical examinations at the time of registration are yearly showing better posture and general physique. The publicity of the physical findings of the draft and the consequent growth in interest in Hygiene and Physical Education is now bearing fruit.

DEFECTS OF THE EYES

Without the use of a cycloplegic, 25% of the men and 32% of the women applying for registration in the fall

of 1922 were found to have errors of refraction of a handicapping severity at the time that they were examined. About 91% of the men and 92% of the women with defective eyesight had their condition uncorrected. Myopia was the most common error of refraction observed. It is more frequent in students from the city. This is due primarily to the racial constitution of the population of large cities, and secondarily to the excessive eyestrain incidental to study, and to clerical and industrial occupations.

As causes of impaired vision, uncorrected astigmatism, short-sightedness and squint aggravated by close work are of the first importance. Dufour has shown that the number of pupils with myopia and the average degree of short-sightedness increases from class to class and with the addition in school demands. This form of myopia is usually primarily due to congenital astigmatism, a very common condition, and to the consequent strain upon the accommodation of the eye in the effort to see. Risley has reported a series of cases in which astigmatic eyes had passed, while under his observation, from hypermetropic to myopic refraction.

Neglected squint is an important factor in the serious impairment and destruction of vision. The bad advice to parents that the child beginning to squint will grow out of it, frequently has led to delay until the eye was practically blind. If the serious consequences of procrastination were known, children would be no more neglected than if they had appendicitis or diptheria.

EAR

Excessive wax in the ear, ceruminosis, was rather a common finding, being present in 16% of the men and 8% of the women. Chronic suppuration of the ear was found in the total of ten cases. This is a very important finding since the condition impairs hearing, is a center of infection that may produce serious complications, and is rarely cured without a surgical operation for the removal of decayed bone.

Middle-ear disease, which causes eighty-five to ninety per cent of all deafness, usually has its origin in the naso-

pharynx and the Eustachian tube. Approximately thirty per cent of the deafness in the United States is due to the suppuration of the middle-ear during childhood. Ten per cent of the discharging ears of children are complications of scarlet fever, measles, or other communicable diseases; in ninety per cent diseased tonsils and adenoids are predisposing causes. In a systematic oral examination of patients with adenoids, Tomlinson found some grade of ear involvement in seventy-five per cent.

Where the function of hearing is impaired, the mentality of the child suffers. He becomes inattentive, in many instances diffident, and frequently a class repeater. Partial deafness, especially when it dates from childhood, is a disadvantage that seldom permits the individual to attain the efficiency of which he would be otherwise capable.

Much deafness would be avoided if disease of the ear were promptly treated by specialists and if parents would see that the adenoids and enlarged tonsils of their children received proper attention. Medical inspection of schools and free treatment for children with disease of the nose, throat and ear whose parents are unable to provide medical care for them should be an important part of any program for the prevention of deafness.

NOSE AND THROAT

Twenty-six and two-tenths per cent of the students examined showed some abnormality of the nose. In the vast majority of cases the conditions were not of pathological significance. Approximately 43% of the defects were due to deviation of the septum and 33% to nasal spurs. Enlarged adenoids showed a very low instance due to removal before examination at registration, the age of the individual, and possibly to being overlooked in rare instances by examiners when rushed. Of the 2955 students examined 17.6% had had their tonsils removed. This is an indication of the greater knowledge of the danger of diseased tonsils. This large per cent of

the removal of the tonsils is a preventive measure of great economic, social, and hygienic significance.

The public is beginning to appreciate more and more that although tonsillitis is generally a mild disease it is not one whose effect upon the patient is always local and one from which the victim always recovers quickly. If it is as Felty believes, a specific streptococcus disease caused by the hemolytic strain of this bacterium, it is a menace to health locally, by extension through the blood stream, by way of the lymphatics, and through the respiratory and intestinal tracts.

Bloomfield and Felty have shown that 40% of the individuals of a large group examined by them when tonsillitis was not prevalent were found to be carriers of the hemolytic streptococcus. Later when certain members of the group developed tonsillitis, the investigators were surprised to find that the ill were among those of the group who were not carriers of the organism. These carriers seem to enjoy immunity during the period of harboring the streptococcus. Spontaneous termination of the carrier state is followed shortly by relatively hypersensibility to tonsillitis. The organisms present in the tonsils of carriers seem to have produced a protective immunity which lasted but a short time after the removal.

From the standpoint of resistance individuals may be divided into two groups; those naturally resistant, who rarely have the disease, and susceptibles who have frequent recurrences with intervals of immunity due to a previous attack and its associated carrier state.

The 17.6% of the prospective students examined who had their tonsils removed had not only gotten rid of a menace to their health but had made conditions in the throats less favorable for the growth for the hemolytic streptococcus. Removal of the tonsils, therefore, would seem to be justified under two conditions; namely, repeated attacks of tonsillitis, and possibly to prevent the individuals from remaining carriers and infecting others. The mere appearance of the tonsils would not necessarily be an indication for excision.

TEETH

The dental examination revealed that every third man examined had defective teeth. In most instances these defects were only slight cavities requiring filling. In a few cases a number of teeth had been lost and consequent facial asymmetry was present. The findings of the dentist emphasize the importance of the care of the teeth to insure proper alignment of the permanent set. It is indeed a rare thing to find perfect teeth in high school graduates. Most of them give their teeth proper attention; a very small per cent are careless of their oral hygiene.

While dental caries is primarily due to bacteria of the mouth acting in the presence of food debris and to certain elements in the saliva which lead to the formation of acid which attacks the enamel, many other factors are predisposing causes. The teeth may have little resistance to decay because of developmental defect, faulty diet, neglect as result of ignorance of parents, cost or lack of dental facilities so common in rural communities.

The ill effects of carious or defective teeth reach beyond the mouth. Decayed teeth may prove the gateway through which pathogenic bacteria reach the blood stream and a root abscess may be the source of arthritis, valvular heart lesions or Bright's disease. Poor teeth are often the cause of indigestion and improper assimilation of food.

With the exception of certain professions and a few individuals in whom the sense of the cosmetic is highly developed, the majority of men and women do not seek their fortune through their faces. The average man or woman, however, desires a symmetrical face. Yet, few parents give sufficient attention to their children's first set of teeth to prevent asymmetry by insuring proper alignment of the permanent set.

GOITER

Thirty-one and eight-tenths per cent of the women and 4 per cent of the men high school graduates showed some enlargement of the thyroid gland, when examined in the

fall of 1922. This gland tends to enlarge during adolescence, but as this swelling seems to be influenced by the locality from which the individual comes, a particular age is not the important factor responsible for the increased size of the thyroid observed. It has been known for a number of years that in certain regions of the world swelling of the thyroid gland was common, and it has been known for a century or more that in America this enlargement is pre-eminently a disease of the Great Lakes' Basin, and its greatest incidence corresponds rather well with that of the hard waters of the Niagara limestone. It is only comparatively recently, however, that this enlargement of the neck was known to occur so extensively in this region and to be common in men, although much less frequent than in women.

Goiter is a disease usually characterized by the enlargement of the thyroid gland which occupies the lower portion of the neck, anterior-laterally. There are two forms of this disorder; simple goiter which is primarily a swelling of this gland, and exophthalmic goiter, an enlarged thyroid accompanied by a distention of the eyeballs, anemia, overactivity of the heart, tremor, muscle weakness, mental irritability, and general organic disturbance.

In the three groups of men and women examined in the falls of 1920-21-22 simple enlargement of the thyroid gland was found to be a health problem of importance in this state. As it is due apparently to iodine insufficiency, it is preventable by the administration of this element, either through such foods as cereals, beets, potatoes, and sea-water salt, or of iodine or its compounds. Prevention of goiter reduces the death rate, increases resistance of the individual to disease, improves his economic status, and promotes his mental, moral, and physical efficiency.

HEART DISEASE

If the hearts of individuals of high school age are carefully auscultated both in the erect and recumbent position and before and after exercise, definite murmurs that are not cardio-respiratory in origin may be heard in from

10 to 15 per cent of those examined. In the great majority of such cases the heart is of normal size, reacts properly to exercise and position, and the diastolic and systolic blood pressure will be found to be within the range of normal. Such individuals enjoy the usual activities of their age without inconvenience or without showing cardiac symptoms of any kind. If this group is carefully observed and repeatedly examined, it will be difficult in most cases to discover anything more indicative of heart abnormality than the murmur. Such conditions are probably functional.

There are, however, of all those examined from 2 to 4 per cent with definite organic heart disease. This latter group is showing a small increase year by year and undoubtedly will eventually go to make up a part of the increasing death rate from organic heart disease in early middle life, unless measures are adopted to protect their hearts.

Heart disease is generally a reminder that entire recovery from infection is often only apparent. The great destruction of life caused by it is usually not the immediate result of acute infection, but rather a slowly progressive failing of the cardio-vascular mechanism due to injuries received originally from such diseases as rheumatism, chorea, tonsillitis, scarlet fever, diphtheria, influenza, or pneumonia. Dublin, in comparing the life expectancy of those who have had typhoid fever, for the three years immediately following the disease, with those who have not had the disease found the death rate in the first group doubled as compared with those who have not had typhoid. It was remarkable that 14.8% of the deaths were due to heart disease, showing that although recovery was apparent the heart was so injured as to cause death in a few years. Lues, of course, plays a great role in the production of heart disease in middle life but was not an apparent factor in any of the cases that came under our observation.

The prevention of heart disease in youth is largely a problem of the elimination of communicable disease. The general adoption of the usual means for the control of epidemic diseases whose complications are involvements

of the heart would undoubtedly be followed by a decrease in the number of cases of this disease found in high school graduates. The high death rate from organic heart disease demands renewed emphasis upon the importance of routine medical examination of the heart and chest. Much will be done in the prevention of this disease when parents, as well as physicians, appreciate the close relation of rheumatism, chorea, and tonsillitis to endocarditis.

It should be generally understood that the symptoms of rheumatism vary in severity from so-called "growing pains" to obvious acute rheumatic fever with an immediate, impending dissolution. The publiic must be so educated as to understand that repeated sore throat and St. Vitus' dance are truly menaces to life, because of the frequent damage to heart valves and to the cardiac muscle.

Both parents and physicians should be on the alert for diseased or permanently enlarged tonsils and adenoids, and should have them removed. The child complaining of tiredness, aching limbs, or who is fidgety or does not desire to work or play should be given a medical examination. Children with even the mildest attack of rheumatism or chorea should receive medical attention and should be watched most carefully to prevent, if possible, the development of inflammation of the heart. The child with an impaired heart should be given close supervision and special school work. Finally, parents as well as the victims of heart impairment should know that a damaged heart, properly treated and cared for in its earliest stages and guarded intelligently through life, is not incompatible with old age and many useful years of service.

HERNIA

The average incidence of hernia among the men graduates of high school registering at the University for the first time over a period of four years is approximately one in twenty-five examined, or 3.7%. A number of these cases observed are of congenital origin or are superinduced by anatomical abnormalities. This condition is also in evidence of the inability of the lower abdominal muscles and fascia to withstand the extraordinary ab-

dominal strain of modern civilization. It may also be considered an indication of man's imperfect adaptation to the erect position.

Chronic constipation, faulty posture, lack of exercise and improper clothes, with the resulting flabby abdominal musculature and sudden strain, are factors in its production. Hernia, to a considerable degree, is preventable. Its presence in young adults is proof of neglected surgery.

SPINAL CURVATURE

While heredity may produce conditions favorable to the development of curvature of the spine, faulty posture is the most frequent cause. Abnormalities of the spine are more common among girls than boys, due, to a large degree, to the differences of dress and the manner of living. Curvature of the spine is part of the price paid by man for the ability to stand erect. The force of gravity is both a predisposing and an exciting cause. Curvature may be secondary to disease and deformity, both of the spine and of other parts of the body.

As only a very small per cent of the cases under consideration are structural in origin, we wish to call attention to them, particularly, as defects of carriage and posture. Happily, the great majority of abnormalities are correctible by physical training and individual attention. Only about 10% of the women and 7% of the men show anatomical abnormalities of the spine that are correctible by gymnastics with difficulty, if at all.

There has been a slight tendency to increase in curvature of the spine among high school graduates during the last four years. This rise, we believe, to a considerable degree is explainable by more careful record of slight deviations from normal. Many of these postural deformities might be described as a slouch or sag and are correctible by the individual himself when his attention is called to it. As his musculature is weak, he needs exercise, otherwise he will resume his old position as soon as his attention is diverted.

In the comparison of the relative frequency of lateral curvature, stooped shoulders, and swayback, scoliosis

is by far the most common deviation of the spine. It constitutes about two-thirds of all spinal abnormalities noted among high school graduates. The comparison also shows that lordosis, or swayback, is more common than kyphosis, or stooped shoulders.

FLAT FEET

While our records show that 35% of the high school graduates examined have some abnormality of the feet, it should be noted that only about 7% of the men and 10% of the women have frank flat feet. Undoubtedly, our statistics include some instances of flat feet that are normal, as it is characteristic of certain races to have flattened arches. It should also be borne in mind that this large per cent is more apparent than real, because it includes a large number of cases of defects in standing and walking that are potential, and not actual signs of pes planus.

We have attempted to discover and to treat flat feet with reference to their predisposing causes by recognizing pes planus as weak feet before flattening of the long arches has developed and the usual train of symptoms are present. The body weight normally passes slightly to the inside of the center of the knee, through a line prolonged from the crest of the tibia, through the ankle, over the dorsum of the foot to the second toe. With the beginning of eversion of the foot and the change of direction of the body weight, it is only a question of time before the symptoms and signs of flat foot become evident.

The importance of muscle insufficiency, improper nutrition and communicable disease in the production of flat foot are shown in the following table, taken from the statistics of Ehrenfried:

Children under twelve years of age examined	1,000
Children with debility of the feet	440
Congenital—club-foot	18
Idiopathic—physical debility	95
Secondary, due to some other condition	327
A. Rickets	200
B. Cases of unsuspected infantile paralysis	107

No comment upon the occurrence of flat feet is complete without emphasis upon the relation of the wearing of ill-fitting shoes to pes planus. The necessity of education directed toward the use of hygienic shoes, proper post-

ure, and of correct methods of walking, is obvious. A study of the geographical distribution of defects of the feet found by Examining Boards under the draft reveals that abnormal feet were comparatively rare in the southern states, due to the practice of the rural part of the population going barefoot and to the negroes, whose feet are not commonly pathologically flat. In the northwest part of the country flat foot is due, presumably, to the large size of the immigrants in this territory. This finding is confirmatory of the role of weight in the causation of flat foot.

Biologically, the relatively high instance of flat foot in young adults indicates that civilization is making demands for adjustment of the feet to modern conditions faster than it can meet them.

The physical and clinical examination of a portion of so representative a group from our population as high school graduates is, in reality, a partial inventory of the physical assets and human liabilities of the nation. Approximately only 7% of all children who enter primary school reach the point in their education where they are about to enter an institution of higher learning. A survey of the physical, mental, and temperamental health of a part of such a group is of great educational, social, economic, and public health interest.

Such a survey gives some indication of the physical, mental, and moral fiber that shows the endurance, persistence, and capacity to meet the increasing requirements of modern education. It reveals something of the ability that, in many instances, overcomes social and economic handicaps to push forward in pursuit of high ideals. It serves as a barometer of the failure and success of man to make complete adaptation to the rapidly advancing requirements of a highly artificial civilization and is, therefore, of biological, racial, and eugenic significance.

Such an inventory provides a rough index of the efficiency of child welfare, and of the care of children during the pre-school age. It gives a rather clear insight into the efficiency of the departments of physical education, and of medical inspections in the community and in the

schools from which these graduates come. It gives more than a hint of the social conditions and the progressiveness and effectiveness of medicine in the various communities in which these graduates live. It is an admirable review of the physical results of competitive athletics upon the adolescent. It is a relatively accurate estimate of the proportion of men in a select group available for military service. It reveals the physical defects which handicap the individual, and justifies itself by increasing his efficiency through correction or alleviation of his condition.

A physical examination is of social and industrial significance since it gives some conception of the suitability of the population for the various occupations which our complex social organization requires. It teaches the laity the nature and value of a good medical examination and stimulates interest in hygiene and sanitation. It gives physicians an opportunity to acquire greater skill in recognizing potential and incipient disease when prevention and cure are most likely to be successful. They get a broader outlook upon disease and have their judgment quickened in the evaluation of symptoms. It benefits society by lengthening the period of activity of those who, by training and experience, will be best fitted to serve it.

A physical examination reveals something of the size and nature of the task before those who seek to raise the physical status of the population to a level more nearly commensurate with the possibilities of attainment. According to the actuarial and medical departments of certain insurance companies, a periodic medical examination has a potential life-saving value of about $30.00 for each such examination.

DISEASES AND FATE OF TWINS

Dr. I. A. Abt, Chicago

It is with the modern biological, rather than with an anthropological, study of twins that the present paper is concerned. Grassl expresses the opinion that multiple pregnancies are neither atavistic nor the result of variation, but simply indicate an excess of the natural or usual fertility.

A. Orgler recorded some observations on twins from his examination of twenty-six pairs. The weight was the same in only five pairs. The difference in weight was more marked when the twins were of different sex. They usually increased in weight at the same rate, though frequently one continued to be heavier than the other for a considerable time, unless one or the other fell ill. He also observed that if both twins fell ill, one of them usually lost more markedly in weight than the other, and when they regained health, both increased in weight at the same rate, though the original disproportion continued for some time.

In a number of cases the heavier child is more resistant and becomes less severely ill when attacked than the lighter one. In a number of cases this does not hold. Frequently there is a difference in the length of the children at birth. While many of them seem to increase at the same rate, in a certain number the increase in length occurs at different rates, so that the one shorter at birth may reach the height of the longer one or even overtake him.

The average weight of twins is approximately equal to the weight of a single newborn. The average weight of uni-sexual twins was 3960 grams, though the female pair weighed 840 grams less than the male. The average weight of the male pairs was 4380 grams, of female pairs 3540 grams, and the average weight of one twin was 1980 grams, though there was a difference in the weight of the sexes. Thus, boys weighed on the average 2190 grams, girls 1770 grams.

Concerning the height of newborn twins, it may be noted according to the statistics of N. Miller that the

average length was 43 cm. and that the girls averaged 3 cm. less than the boys. The average height of boys was 45.5 cm., that of girls 41.5 cm. Newborn twins, especially those of the same sex, may be approximately of the same height and weight.

On the other hand, there may be great disparity in their weights, varying from 200 to 800 grams and, in extreme cases, even 1000 grams. Differences in height are also noted. Sometimes one infant is 2.5 cm. longer than his mate.

Differences in the development may be accounted for at times on a purely mechanical basis. In some instances the nutrition of the two fetuses is unequal. In one case the umbilical cord may be short and straight, in the other one, long and winding. It is evident that in the former the blood supply would be greater and the nutrition would be better. At other times, one placenta is located favorably on the uterine wall, and the other one is attached in an unfavorable position. The greater the respiratory surface of the placenta, the better the fetus develops. In other words, the larger the placenta, the more closely it is approximated to the uterine decidua, and the more favorable are the conditions of the fetus.

Newman states in his "Physiology of Twinning" that there is a popular impression that in human twins one is usually stronger and more vigorous than the other. Practical experience tends to bear out this impression. Even in identical twins, there is usually a more vigorous twin who is the dominant member of the combination. One twin tends to gain a physiological ascendancy over the other to the slight or very great detriment of the latter. Spaeth found no evidence that the twins of either type had any definite physiological effect upon each other, though he grants as an evidence of inter-influence the condition of *situs inversus viscerum*. Newman points out the disadvantages of twinning by saying that when two or more fetuses come to occupy the space usually filled by one, the twins, whether of the one egg or two egg type, crowd each other and compete for the common food supply. In the case of two egg twins, the competition is for placental surface.

The period of uterine gestation is at best a hazardous one. In addition to those hazards that are met by single embryos and by two egg twins, there are certain very serious special dangers that fall upon one egg twins by reason of their close genetic relationship. One egg twins vary according to the period when the placenta is developed, and consequently one may receive more nutriment than the other. Moreover, on account of the difference in the blood supply to the two fetuses, one is more favored than the other, a condition which may even lead to the death of the less favored. Because of these variations in food supply and as a result of one fetus crowding upon the other, there is not only a disproportion in size and weight of the two infants, but malformation and conditions of arrested development may be noted in the weaker twin. Thus, one of the pair may be strong and healthy at birth, the other weak and delicate physically and defective mentally.

In my practice I have such an instance. The weaker one was extremely difficult to nourish, was very much retarded physically, and has remained defective mentally, while the other child developed rapidly and normally. The twins are now fifteen years old, the one a tall, bright, well-developed girl, while her sister is infantile in size and has attained no mental development. I recently saw a pair of male twins, three years old. One was bright, well grown, and his development was perfectly normal. The other weighed only twenty pounds at three years, teeth developed late, and his static development was markedly delayed. He was mentally much retarded and unable to talk. The normal twin's birth weight was six pounds, the other's three pounds. Instances of this kind must be very frequent.

Dentition may occur at different periods in the two infants, and this does not always depend on the severity of the rickets. In one pair that seemed free from rickets, the first dentition occurred at the seventh month, while the other infant developed his first teeth two months later. At ten months the first infant had eight teeth, while the other had only two. The difference be-

tween the eruption of teeth in the two babies may be as long as four months.

Francis Galton made a study of twins from the biologic and genetic aspects, and hoped to be able to differentiate between the effects of tendencies received at birth and of those that were imposed by the special circumstances of their afterlives. He sent questionnaires to persons who were either twins or near relatives of them. He received eighty replies, thirty-five of which entered into instructive details. In a few of these not a single point of difference could be specified. The color of the hair and the eyes was almost always identical. In many instances the twins were of the same height, weight, and strength. In others there was a notable difference in these factors, though the resemblance was in other respects close.

Gesell reports twins who showed superior intellect. They both sat up at six months, walked and talked at eleven months, learned French at three years, and were in the seventh grade at the age of nine. They resembled one another, both physically and mentally. In fact, there was no noteworthy distinction between the two. Their physique, countenance, demeanor, conversation were completely similar.

Homologous twins usually show marked similarity physically, as well as mentally. They resemble each other in weight, body structure, voice, and gait. They may learn to speak and walk at the same time. Not rarely they show the same anomalies and faults of development. They may become sick at the same time and die almost at the same time.

Ganther and Rominger studied the finger prints of five pairs of one ovum twins and forty-two pairs of two ovum twins.. They found that in the five pairs of one ovum twins there was marked similarity in the finger prints, and in the system of lines of the hands. In the two ovum twins there is a certain similarity of structure, but never the striking correspondence of the system of lines. They conclude from their studies that a striking similarity of the structure of the lines of the hands indicates that the twins are uni-ovular.

Miller describes 247 pairs of twins of the same sex which he studied at the Moscow Findelhaus. He assumed that thirty were homologues. Twenty-three showed similar or analogous malformations. In five pairs the twins had hypertrophic umbilicus. Four had dolicocephalic skulls and four others congenital phimosis. Two had congenital depressions of the sternum. Two other pairs had marked shortness of the frenulum of the tongue.

Some of the twins showed anomalies occurring in both during the early days of life as a result of acquired disease. Thus, two boys had simple pemphigus. Two other male twins both developed mastitis on the left side, followed by erysipelas. They both recovered practically at the same time.

The temperature of twins sometimes varies at birth. One infant may show two- to three-tenths of a degree higher temperature than the other. As a general rule, well-developed twins have a slightly higher temperature than those who are weakly.

Prematurity. Twin pregnancy is a relatively frequent cause of premature birth. Ylppö's series of prematurity showed that out of 688 cases, 19.2 percent, or 128 cases, were twin babies.

The prematurely born, whether singly or in pairs, are predisposed to a variety of disorders. The susceptibility of prematures to rickets is a common observation. Huenekens found that of seventy cases of premature twins, fifty-eight developed definite signs of rickets. He observed that the condition appeared sometimes before the fourth month of life. Craniotabes, an early symptom, may be present in the sixth week of life.

Other rachitic manifestations occur in premature twins as well as in prematures of a single birth. Among the early symptoms may be mentioned rachitic rosary and rickets of the long cylindrical bones. In premature infants there is a deficiency of the calcium content, as well as of other mineral substances. By the third or fourth month, there is a lowered phosphorus and calcium content, and rickets and its sequelae result.

Premature or underweight newborn twins frequently manifest spasmophilic diathesis and tetany. Evidence of spasmophilia may be found in these infants even if they are born at full term. An instance is cited where, in a pair of twins, the one developed laryngismus stridulus, facial phenomenon, and electrical over-excitability, giving all the symptoms of spasmophilia, while the other remained free from this disorder. It has also been observed that craniotabes may be present in one infant and absent in the other.

Langstein reports a case of twins in whom convulsions always appeared when artificial food was used as a substitute or complement for breast feeding. It should be noted, however, that the twins did not develop the tetany at the same time. One pair developed spasmophilia within seven to twelve days after the administration of artificial food, the other eighteen to twenty days thereafter.

A pair of twin girls, nine weeks old, came into my service on the 19th of July, 1922. The first one had convulsions lasting three days. The other twin had convulsions which lasted a week. They both had marked craniotabes, Harrison's groove, slight rosary, and protuberant abdomen. The Chvostek sign, as well as carpopedal spasm, were present in both. Both were breast fed. Thus, it is evident that these nine weeks old infants had almost similar attacks of tetany with florid rickets.

In twins not prematurely born, rickets and spasmophilia in both children is a frequent occurrence and is commonly observed. Orgler records in his series a case of rachitic twins where the degree of intensity was different. The one was severely affected, the other only moderately. He also recorded a case in which one child had developed scurvy, the other had not. Alfred Hess says that twins have a special tendency to develop rickets, and this is partly due to a sub-normal quota of anti-rachitic constituents stored in their tissues and also to the variable susceptibility of infants to rickets.

Anemia. The anemias of prematures may be of a high degree and may be prolonged into the second and

third year, though this condition may occur in children born at term.

A pathological anemia occurring in twins may affect one or both. The hemoglobin is usually low and the reduction may be observed during the first days of life. Occasionally one or both parents show marked debility or anemia. Charles Herrman states that twins and single infants born prematurely come into the world with an imperfectly developed blood forming system and, if some injurious external agent affects the infants, this latent inferiority soon manifests itself. He says that some of these infants show their anemia from birth, some not until later. Von Jaksch's pseudo-leukemic anemia may occur in one or both twins. Finkelstein reports twins who developed a clinical type of pseudo-leukemic anemia after infections.

Chlorotic anemia has been described from Finkelstein's clinic by Kunkel as occurring in prematures and twins. Kunkel's investigations considered the blood changes in premature and feeble children. Among this group were seven pairs of twins, sixty prematures, seven feeble children. He found that most of them suffered from a chlorotic type of anemia characterized by oligosideremia and slight diminution of the cellular elements of the blood. Spleen and lymph nodes are not enlarged. This form of anemia occurs very early in life. This is particularly true of the prematures. Kunkel gives several instances where the twins were much below normal in weight and the anemia continued until one infant was four months old. At that time his hemoglobin was forty-three per cent. When the children were taken out of doors, the condition improved, though at the sixth month the hemoglobin content had reached only sixty per cent. Occasionally only one of the infants becomes anemic, though as a rule both are affected, but there may be a difference in degree. Senator reported a case of splenic leukemia which developed in twin sisters of eighteen months; both died about the same time.

Mental Affections. Mongolian idiocy may occur in one or both twins, though in the majority of the cases only one of the pair is affected. Halbertsma quotes sixteen

instances where one of the twins was a mongol and two where both were mongols.

The mental affections of twins do not differ in form or in frequency from those of other individuals. A limited number of psychic disturbances have been reported which do not differ from those encountered in children of single birth

Epilepsy of both children with mental deficiency is reported. A few cases of dementia precox have been recorded. Hydrocephalus occurred in a pair of twins. One was delivered by craniotomy, the other was born spontaneously. There was no syphilis or alcoholism in the parents. The father was by occupation a painter, but did not suffer from lead poisoning. The second infant died on the twelfth day.

Soukhanoff made an analysis of thirty-three cases of insanity in twins in 1900. In some there were congenital mental defects, in one dementia precox, in one general paralysis. In most cases the twins were uni-ovular, alike in appearance and mental character, and the form of insanity in each pair was the same.

Infections. According to Orgler's observations, the behavior of twins towards infectious and nutritional disturbances was not always the same in both. One twin became ill with bronchitis, while the other developed whooping cough. The first recovered in two weeks, while the latter remained ill for two months.

They often reacted differently to infectious diseases. One twin died of generalized miliary tuberculosis, while his mate developed tuberculides and a strongly positive Pirquet reaction and the disease ran a more protracted course. In those instances where one twin developed rickets or exudative diathesis, the other had it also, though the intensity of the manifestations was frequently variable, the disease being intense in one child, mild in the other.

There is also recorded a case of single ovum twins who seemed to be similar physically and mentally, but who showed some difference in their resistance to infection. Whether this difference in resistance is peculiar to one ovum twins cannot be definitely stated. It may be as-

sumed that there has been an unequal division of the germ plasm in the uniovular variety which might account for the variable behavior to infection.

Three sets of double ovum twins, observed by Orgler, showed uniform behavior to infection. However, in the case of twins of opposite sex who were admitted to the hospital at the age of five weeks and remained there for a considerable length of time, the boy, at the age of six months, developed measles, while the girl remained free from the disease, notwithstanding the fact that they occupied adjoining cribs.

Ballantyne in his "Antenatal Pathology and Hygiene" records a case where both twins acquired variola from their mother. In another case, one was affected while the other escaped. In a third, both fetuses exhibited the eruption. One presented many pustules, while the other had only a few.

During infancy and early childhood, twins, like other siblings, develop almost simultaneously intestinal upsets, grippal infections, measles, mumps, chicken pox, scarlet fever, and other infections.

Syphilis. Where one or both parents are syphilitic, the twins, as a rule, suffer the same fate as does the fetus in a single pregnancy. There are cases recorded, however, where one of the twins presents evidence of manifest lues while the other seems to remain immune. Grete Singer reports twins, a girl and a boy, one of whom was clinically and serologically luetic, the other normal. The non-infected infant showed negative Wassermann reactions during a period of two years.

Finger reports cases of dissimilar severity of syphilis in twins, i. e., one was more severely affected than the other. There are numerous corroborative reports in the literature, in which one case was syphilitic, the other healthy. Rosinski reported syphilis in twins. The boy showed severe symptoms of hereditary lues. The girl, who was observed for twenty-four years, remained entirely free from the disease. No satisfactory explanation can be found for this inequality in the distribution of the disease. Why one child should be infected and the other remain free is difficult to conceive. It has been

suggested, however, that the difference in the severity of the disease is due to different modes of infection. It is thought that this is more probable than that there is a difference of immunity in the two fetuses.

Mortality. Twins in general are characterized by low vitality. The death rate is much greater than in single newborns. In the first weeks the mortality is forty percent. It is generally stated that twins have thirteen times less chance to live than ordinary newborn babies. In the report of Miller's cases at the Moscow Infant Asylum, 3883 pairs of twins were observed among 277,902 children. 62.9 percent of these died during the first weeks of life. In half of the cases, both twins died on the same day. In the remainder, the one lived one or two days longer. Septicemia and syphilis were frequent causes of death. The greatest mortality of those infants who survived the first few weeks of life seems to concentrate in the first and second year. After the fifth year of life, the mortality of twins and non-twins is about the same.

It has been estimated that out of a hundred pairs of twins born there are eighty pairs who survive. In fifteen pairs, only one child survives; in five pairs both children die. According to Hecker, fifteen percent die during the first eight days. It has also been said that twin girls seem to have greater viability than twin boys.

Since Galton's memorable studies no investigation has been conducted on the pathological aspect of twins. The British Medical Journal of 1912 contained a very interesting and suggestive editorial on twinship and fame. The editorial was suggested by the remarks of Doctor Kaiser, of Dresden, who stated that he knew of no famous man who had a twin brother. A similar query had been raised by Doctor Simpson in the Edinburgh Medical Journal of 1862. Simpson was not aware of a single instance in which a twin had distinguished himself intellectually. The editorial writes takes issue with these gentlemen, and goes on to show that there were several twin brothers who had won more or less fame. In attempting to collect information on this subject, it

was found that no records of morbidity or mortality in twins were available.

It is to be regretted that there are not more data at hand concerning the development, physical and mental, of twins during their later lives. To make such data available, it would be important for obstetricians to record in every instance whether the twins originated from one or two eggs, which information should also be supplied to the families. Parents, physicians, teachers should be able to furnish significant information. Twins themselves, or their friends, might in some instances contribute important biographical sketches, and life insurance companies and bureaus of vital statistics should furnish details about the causes of death. Information of this kind would be of great interest, if not of practical value, to a great number of people. Knowledge of such facts would constitute a noteworthy contribution to medical science.

ALLERGY OR PHENOMENA OF HYPERSENSIBILITY

RALPH W. NAUSS, M. D., ILLINOIS DEPARTMENT OF PUBLIC HEALTH, SPRINGFIELD

Hypersensitiveness in man may follow after both the enteral and parenteral introduction of many and varied substances. These inducing substances may be antigenic or non-antigenic in character, i.e., those which stimulate or those which do not stimulate the production of demonstrable antibodies. The response to these substances in man are usually thought of as due to personal idiosyncracy and the symptoms, however diverse the inciting agents may be, have a great deal of similarity. The term allergy, meaning literally altered energy or work, was first introduced by Von Pirquet after whom the well known skin test in tuberculosis has been named. Coca[1] has suggested that this term allergy be applied only to the phenomena of hypersensibility in which the reaction is not due to antigen-antibody combination, or at least where the antigenic property has no direct bearing on the reaction.

Symptoms elicited in man by the introduction of serums with or without antitoxin may, according to Parke[2], be divided into those following *first* the initial injection and *second*, those following the second or later injections. These reactions have nothing to do with the antibody content of the injected serum. Following the first injection three types of reactions may be noted:

(a) Collapse with or without fatal outcome;

(b) A symptom-complex termed "serum sickness", and finally—

(c) Local necrosis.

Each of these forms of response may also follow the second or later injections.

Collapse or Death.—This accident is rare and nearly always occurs after the first injection. The symptoms appear quickly after administration. According to the most reliable statistics, about 1 in 20,000 primary injections of antitoxin results in alarming symptoms (in about 1 out of 50,000 injections death occurs), the out-

standing features being those of extreme dyspnea and collapse. The dose may be small, in one instance reported about 1 c.c. (500 units) of antitoxin having been given subcutaneously. Kerley[3] reports a case of known-hypersensitiveness where the dose was gradually increased until 5 minims were given, resulting in alarming shock. Persons showing this type of reaction are frequently found to be subject to asthma or hay fever, being subject to the former particularly in the vicinity of horses or stables. Nearly all children dying after serum-shock are cases of "status lymphaticus".

After the intravenous injection of low-potency antitoxin even when the material is warmed to the body temperature and the injections given very slowly, chills more or less severe in character are observed in nearly half of the cases. Park[2] suggests that this is probably due to a special form of the protein possibly in the state of a fine flocculent precipitate. According to his experience less than 1 per cent of intravenous injections produce a chill when the best products are employed, whereas this undesired symptom occurs much more frequently when less perfect serums are used. In some instances the intravenous administration of antitoxin or other serum several weeks or longer after an initial injection which caused marked reaction, results in alarming symptoms of collapse. This effect is said to almost never follow a second subcutaneous injection. In other instances frequently repeated intravenous injections of serum develops instead of desensitization a hypersensitiveness so marked that even small amounts of serum give a sharp reaction. Such conditions are, fortunately, known to be relatively very infrequent.

Serum Sickness.—The occurrence of this type of reaction according to Park[2] varies considerably in different series of cases, from ten to sixty per cent or more, the size of dose influencing this incidence. Concentrated globulin preparations of antitoxin cause a relatively low incidence. Following the first injection of antitoxin or other serum there occurs an incubation period varying from three hours to twenty-four days (more commonly from three to twelve days). The symptoms primarily

consist of a skin eruption, edema, slight albuminuria, enlargement of the lymph nodes with pain and tenderness and pain in the joints. The eruption is variable in character, a local eruption usually appearing earlier than the general eruption. On the second or later injections the period of incubation may be absent or shortened (immediate or accelerated reaction). This does not, however, always occur. This condition is not considered serious and in many instances gives no greater discomfort than that of an itching rash. Some samples of antitoxic or other sera quite uniformly cause a skin eruption. The earlier rashes are usually scarlatinaform, while those occurring later are more frequently of an urticarial nature. Von Pirquet and Schick believe that this reaction is due to antigen-antibody combination, owing to the fact that the average incubation period coincides with the time of first appearance of precipitins in experimental animals. It is known, however, that precipitins may be present without any manifestations of allergy whatever.

Local Reactions.—The primary injection of antitoxic or other sera may lead to local necrosis. When repeated injections are given, a final subcutaneous injection will more frequently result in a sharp local reaction, which may terminate in necrosis. This may also occur with rabies vaccine as well as with serum and is thought to constitute a striking parallel to the so called Arthus phenomenon in rabbits. It has been shown that such necrosis is not due to bacterial contamination, but the necrotic area may become infected and serious or even fatal consequences follow.

In connection with these serum reactions, there are certain preventive measures which should be mentioned briefly:

(1) *Desensitization to Serum.*—It is a well known fact that different lots of antitoxic or bactericidal sera will vary widely in their rash and temperature-producing qualities. This may have a bearing on the development or non-development of untoward symptoms. The administration of small doses of serum prior to the first injection or previous to subsequent injections of those known to be sensitive to the same is frequently resorted

to in order to desensitize. This procedure in man does not, unfortunately, give the same uniform results as noted in experimental animals. It may be said, however, that divided doses, although they may fail to give the reaction, or repeated small doses may induce a tolerance, but this is not considered proof that we are inducing the mechanism of desensitization so uniformly observed in experimental animals.

(2) *Prevention of Serum Reactions.*—Persons who give a suspicious history should be tested cutaneously for evidences of hypersensitiveness. The appearance of a wheal at the site of injection indicates that the person so tested will show a fairly immediate serum reaction, such as rise of temperature or urticarial rash, but is no indication of the probable severity of the same. The absence of such a skin reaction indicates, but does not prove, that there will be no undesired results following the administration of the serum. The procedure usually followed and recommended is to inject the antitoxin or other serum in divided doses every 20 to 30 minutes, starting with 0.1 c.c., until symptoms are observed or until sufficient is given. If symptoms develop one can then attempt repetition of smaller doses which previously did not cause symptoms. Where serum is to be administered intravenously, dilution and exceedingly slow administration in the beginning will tend greatly to prevent undesirable results. Intraspinous injections should also be given slowly, especially the initial portion following a recent previous injection. Hypodermic injection of atropin or epinephrin will usually relieve the less severe attacks of serum shock. In cases of extreme collapse, artificial respiration should be resorted to.

Allergy to Foods, Pollens, Etc.—After the ingestion of specific foods, rashes and other forms of reaction occur in a small percentage of individuals. These may follow the eating of eggs, certain kinds of meat, including fish, fruits, etc. As stated above, the inducing substances may or may not be antigenic in character. Hay fever is an example of mucous membrane hypersensitiveness. Persons suffering from this condition may also show skin sensitiveness and even develop rashes or other

symptoms when the inciting substance is injected. Such hypersensitiveness may be manifested toward certain pollens, dust from the hair or skin of animals, powders of various kinds, etc.

Experimental study of pollen extracts appears according to Park[2] and others to show that they do not stimulate antibody production nor will they sensitize experimental animals. One might infer from this that hay fever (and probably food allergy also) is not due to sensitization of the individual, but possibly to some inherent or early acquired predisposition. Where hypersensitiveness toward a specific agent exists, the same is not necessarily an inherited condition. Increased tolerance to these classes of allergy may frequently be developed through the repeated use of small doses of high dilutions of the inciting substances. This is, however, only relative and is not comparable to the regularly induced and quantitatively greater resistance of desensitized animals. Varieties of dermatitis due to poison-ivy, sumac, etc., are claimed by some to be caused by similar hypersensitiveness. This, however, is questioned by many.

Drug Allergy or Idiosyncracy.—Allergic symptoms due to drugs follow a dose or doses which are not appreciably toxic for most individuals. The symptoms resulting are said to be due to idiosyncracy, because they are different from those obtained with larger and uniformly toxic doses. Substances which usually give rise to this kind of allergy are mercury in various forms, salvarsan, iodides, quinine, morphine, antipirin, salicylic acid, turpentine, cubebs, sandal-wood oil, etc. The symptoms usually observed are quite severe, with or without chill, skin eruptions, local edema or gangrene at the site of injection, swelling of the joints and lumph nodes.

Speaking of human allergy in general, there appears as already intimated to be little or no evidence that the basis of these phenomena is an antigenic-antibody reaction. The dominant feature in human allergy rather appears to be that of idiosyncracy. A condition resembling anaphylaxis has been observed only in a small number of cases. We refer here particularly to symptoms of

collapse after a second injection and local necrosis after repeated injections. Failure to get in man the typical picture frequently observed in experimental animals may be due to the relatively smaller doses given, the usual dosage being much lower per unit body weight than necessary to cause shock in animals such as the guinea pig. In case of intravenous and intraspinous injection in man the factor of quick absorption must not be lost sight of and guarded against.

Hypersensitiveness and Infection.—In many communicable diseases there develop varying degrees of hypersensibility to causative agent. The most extensively studied and best known examples of this are infections due to the tubercle and the glanders bacillus. Tuberculin, which consists of the soluble products found in a broth culture of the tubercle bacillus, is only toxic for an infected animal, i.e., infection results in hypersensitiveness. Such hypersensibility may be demonstrated in the skin, mucous membranes and also by a systemic and focal reaction (site of lesion) when injected in sufficient doses. Too large a dose may result in death of the sensitive animal. Tuberculin is highly resistant to heat, and is specific but not anaphylactogenic. A relative tolerance may be induced in the tuberculous animal by gradually increased doses. This substance differs further from all similar substances in that animals cannot be rendered hypersensitive by its injection experimentally. On the other hand, the proteins of the tubercle bacillus are anaphylactogenic. This is a distinctly different phenomenon. The real mechanism of the tuberculin reaction is still obscure.

A similar skin reaction may be obtained in a considerable proportion of syphilitic cases by the intracutaneous injection of "luetin," an emulsion of the Treponema pallidum. Indications of hypersensitiveness have also been noted in typhoid fever or following the injection of typhoid vaccine. Likewise, positive skin reactions have been found to follow the injection of the genococcus and in such conditions as Leprosy, Sporotrichosis and other diseases caused by fungi and in pregnancy. All these

reactions are relatively specific but have been observed mostly in experimental animals.

Vaughan[4] believes that the parenterally administered protein excites the release of specific ferments that are capable of splitting the protean molecule in such a manner as to give rise to a toxic product. In a similar manner, he contends that the symptoms in the acute stage of the various contagious and infectious diseases are produced, the protein of the various bacterial growths being split by the ferments set free from body cells. The term albuminal he applies to these diseases. The comparatively few bacteria gaining entrance into the body must multiply, and this is accomplished during the so-called period of incubation. There is no apparent resistance during this time on the part of the body cells. The latter must be sensitized before they can begin their combat with the invading organisms and it is not until this actually takes place that active disease symptoms manifest themselves. This theory is dependent on the assumption by Vaughan and Wheeler[5] that the process which results in the production of protein poison causes a splitting of all of the molecules in the material subjected to it. This assumption they consider proved by the observation that the non-toxic residues sensitize animals against the original protein but not against itself. This opponents claim is fallacious because the amount of protein required to sensitize a guinea-pig is but a minute fraction of that necessary to intoxicate or desensitize the sensitized animal.

Hypersensitiveness and Immunity.—Sir Edward Jenner observed that the reaction following vaccination after a previous typical vaccinia (cowpox) appeared earlier and ran a shorter course that is the case in typical primary vaccinia. Of recent years this observation has been studied by Von Pirquet, Tieche, Force and others, and the evidence clearly indicates that such an accelerated response to vaccination is an indication of immunity. In case of tuberculin the reaction is also said to be indicative of immunity to reinfection. The disappearance of the reaction in a person with a latent lesion, during measles for instance, is not infrequently followed by

extension of the lesion and active tuberculous disease. Professor Gay[6], of the University of California, attempted to show that the appearance of a positive skin reaction to typhoidin is an indication of immunity to typhoid fever. This, however, is not exactly the case, since this reaction is absent or disappears at a time after infection or vaccination when immunity is still known to exist. More recently an intracutaneous method of diagnosis of whooping cough[7] during the first weeks of this disease was advocated. This, however, has been shown not to be a specific reaction. In fact attempts to duplicate published results by Hull and Nauss[8] show conclusively that identical reactions may be obtained through the injection of quite different inciting substances.

Within a few months also an intracutaneous method of diagnosis of scarlet fever based on recent investigations of the etiology of this disease has been published[9]. This, if satisfactorily confirmed, will prove to be a great boon not only to the practicing physician but also to the health administrator. It may be pointed out further that the possibilities of development in this field have not by any means been exhausted. The exact and rapid laboratory diagnosis of both infection and immunity in many other communicable diseases offers sufficient stimulus to both investigator and hygienist as to warrant the most exhaustive researches.

As a recent development of the application of this principle, the Schick test in diphtheria deserves special mention. Similar to most allergic reactions in man, this is not of the nature of anaphylaxis. In fact, it may be looked upon as a comparatively simple case of a biological chemical reaction confined for the most part to the site of injection of the active diphtheria toxin. The Schick test runs quite a definite course, which will be illustrated in connection with a series of lantern slides, which are to be thrown upon the screen, showing various local manifestations of allergic skin reactions.

As aids to the diagnostician, these various local manifestations of allergy may be divided into two general classes; namely, those which serve as *indices of infection*

and those which serve as *indices of immunity*. To recapitulate, among the former are the tuberculin, mallein, luetin and other similar and theoretically possible tests. Among the indices of immunity, the principal ones are the accelerated and immediate responses to vaccination against smallpox, the serum test preliminary to the administration of antitoxic and other sera, the Schick test in diphtheria, and the many and varied tests utilized in the determination of sensitiveness in food idiosyncracy, hay fever, asthma, etc.

BIBLIOGRAPHY

1. Coca, A. F.: Hypersensitiveness. Tice's Practice of Medicine, 1920.
2. Park, W. H.: Hypersensitiveness. Public Health and Hygiene, 1920.
3. Kerley: Arch Pediat, 34;459, 1917.
4. Vaughan, Victor C.: Albuminal Diseases. Epidemiology and Public Health, Vol. 1. 1922.
5. Vaughan and Wheeler: Jour. Infect. Dis., 1907, 4:476.
6. Gay and Force: Archiv. Int. Med., 1914; 13:471.
7. Orgel: A Method for the Early Diagnosis of Pertussis, Jr. A. M. A. (Oct. 28), 1922. 79:1508-09.
8. Hull and Nauss: Intracutaneous Reactions in Pertussis' Jr. A. M. A. (June 23), 1923. 80, 1840:41.
9. Dick and Dick: A Skin Test for Susceptibility to Scarlet Fever. Jr. A. M. A. (Jan. 26), 1924.

MANUFACTURERS' INTEREST IN PREVENTIVE MEDICINE AND SURGERY

LeRoy Philip Kuhn, M. D., Chicago

When the United States decided to build the Panama Canal, the first great problem confronting our Government was, "How can our workmen endure the diseases prevalent in this section until the stupendous task of engineering can be accomplished?"

The French did not realize in 1877 when Ferdinand de Lesseps, a great French engineer, attempted to dig the Panama Canal, nor did they realize when they tried again in 1884 to 1889, that the "stegomyia mosquito" was the chief reason why they could not progress with this wonderful undertaking. The United States, recalling the experience of France and the great engineer who had previously built the Suez Canal, realized that it was necessary for the Government to find a means of eradicating not only yellow fever, but bubonic plague and malaria in order to go on with this great piece of engineering and do something France had been unable to do up to that time.

Our Government at once realized that the first step was to clear this zone of disease so that our men could work and live in reasonably healthy surroundings. After a survey of our possibilities, the surgeon general's office was called upon. General Gorgas was ordered to report to the Commission as Chief Sanitary Engineer for the Isthmus. Our Government had to be convinced first that it would be necessary to conquer the mosquito before any work in the Panama region could be undertaken safely. It required quite a sum of money for the Commission, composed of General Gorgas, Dr. Carlos Finlay, Dr. Antonio Albertini, and Dr. Juan Guiteras, who cooperated with the Walter Reed board, to go on with their work, but with General Gorgas' enthusiasm and his staunch belief in his proposed methods, his immediate initiative, and his great industry overcame all obstacles, and between the time of the announcement of the plan on February 1, 1901 and September 15, 1901, a period of less than eight months, he eradicated yellow fever from

Panama where it had extended continuously for over one hundred and fifty years.

If sanitary conditions had remained as they were previous to 1901 and we had lost, as did the French, 200 of our employes out of every thousand on the work, we would have lost 7,800 men each year, and 78,000 during the whole construction period; thus, the Gorgas sanitary program saved the difference between 78,000 estimate of deaths under the old regime and the actual 6,630 deaths under the new, or a total of 71,370. General Gorgas estimated that the saving to the United States Government, due to the work of sanitation, was a total of $80,000,000.

The Walter Reed board, working under General Gorgas, not only conquered the "stegomyia mosquito", and the "anopheline mosquito" which produced malaria, but also conquered the rat flea which transferred from the rat to the human being the dreaded disease known as "bubonic plague."

"The Canal Zone," says General Gorgas, "for the past 400 years, ever since it has been known to white man, has been one of the most unhealthful spots in all the tropical world and now it is one of the garden spots of our civilized world, with a health condition excelled by no land."

Many of the great problems were brought to the attention of the medical profession at a time when progress was impossible. Did you hear of typhoid, malaria, or yellow fever epidemics during the great World War? No. You say, "We did hear, though, of the flu epidemic which caused a death rate nearly as great as the number killed and wounded in battle." How our laboratories worked during this epidemic to find the direct cause! Eventually, we will find a way to conquer influenza as we did typhoid and malaria.

When the different Workman's Compensation laws went into effect a few years ago, there was a material increase in the number of accidents, due largely to the fact that all accidents had to be reported. Only a short time before, employers realized that by active safety prevention a marked saving in time and suffering of the employe could be produced. Immediately, safety devices,

guards of all descriptions were utilized to prevent accidents. What has been the result of this universal movement to establish safety, not only in industry, but upon the public highways?—Reduction in the number of accidents to employes and making our streets safe for pedestrians.

The Division of Factory Inspection of the Illinois Department of Labor reports that preventive measures are more rigidly and widely used by employers than was the case when factories were merely under police power of the Factory Inspection Department. Furthermore, employes are certain of immediate benefits, employers escape expensive court procedures with large sums for damages in some cases, and the public is benefited by actual reduction in sickness, as health measures are more generally adopted.

One of the constructive measures adopted by the Illinois General Assembly of 1923, upon which employers and employes were able to agree, was placing occupational diseases under the provisions of the Workman's Compensation Act. In order for science to progress, there must be individual cooperation with public efforts. The making of laws without interest and cooperation of parties prevents current efforts from being effective to any adequate degree.

We must admit there is much economic waste in industry as the result of absence from work, caused largely by avoidable illness and physical disability. Employers realize the necessity of physical examinations of workmen and, where indicated, medical service is a part of the routine equipment of the personnel management of industries. The employer may, however, ask if these remedial measures pay. It is not a mercenary question, but one upon which the future generations depend. If need be, the cost of the article manufactured could be increased sufficiently to cover additional expense, so that the workman and his family might be protected.

There are approximately 42,000,000 gainfully employed persons in the United States. More than 25,000,000 of this group have defective vision of sufficient degree to handicap them in their work. A large number

are employed in Illinois. We all know defective vision is a liability. Correct these defects and the procedure would result in increased production, better workmanship, minimized waste, smaller number of accidents, greater individual comfort and efficiency.

The economic value of good eyesight to the industry of this country, although difficult to measure, can hardly be overestimated. Careful examination shows that above 60 percent of employes have defective eyes. The fact that this can be almost entirely remedied makes its continuance inexcusable. Frequently a person is found to be practically blind in one eye without being aware of it. A person so afflicted, if injured, may claim compensation that is not justifiable.

Over one hundred years ago Dr. Benjamin Rush, after whom Rush Medical College was named, wrote a book on medical practice, and in the first chapter cites many cases in which patients suffering from rheumatism and other maladies either were cured or greatly improved by the extraction of teeth.

More than a century ago in England examination of the teeth of school children was considered a routine procedure.

Teeth of the average adult appear to have been neglected, judging from the evidence of 6,000 x-ray pictures taken a few years ago of the mouths of 600 adults of the average age of twenty-eight years. These pictures showed over 1,500 treated teeth and an average of 5½ teeth missing for each person. Allowing for a few who never had wisdom teeth, we might say that an average of four teeth for each person had been extracted because of neglect of cavities of decay. These same x-ray pictures showed that 51 percent of these 600 adults had infected areas at the ends of roots of one or more teeth, and 53 percent had parts of the bone along the sides of the roots destroyed by the infective process known as pyorrhea. Of the entire 600, 78 percent had one or the other or both types of infection. Nearly every leading physician will tell you that infections of the teeth are by far the most frequent causes of secondary infections elsewhere in the body. The lack of attention to the teeth

of our children and adults results in a series of disabilities which is without doubt cutting short the lives of many people.

What has been accomplished in Illinois to reduce tuberculosis, can be done with respect to cancer, heart disease, eye strain, kidney disease, and many of the preventive disturbances.

During the days of epidemic and pestilence it was considered good evidence of normal health to avoid death. People would expose themselves and their children to mild cases in the hope that they might contract a mild form of the disease. It never occurred to those people that they might entirely avoid pestilence. Their only thought was not to die of it. There was a great improvement during the first part of this century in the avoidance of certain infections, those infections especially referring to infancy.

Our struggle in this age is not only to prevent infections and contagious diseases, but toward perfecting health. A healthy body can be made a positive asset. It is one of the necessary foundation stones, not only to prevent disease, but also for development.

A statistician published figures showing that in 1921 there was expended in the United States an average per capita of $10.00 for candy, $9.00 for education, 50 cents for chewing gum, and 29 cents for health.

We must not forget that the power of our nation and the happiness of our people depend upon the health of individuals.

A NEW PRINCIPLE ESSENTIAL TO CORRECT SPEECH IN THE TREATMENT OF COMPLETE CONGENITAL CLEFT PALATE

TRUMAN W. BROPHY, M. D., CHICAGO

The subject of defective speech due to congenital defects of the lips and palate claimed the attention of surgeons as early as the beginning of the Christian Era, the lip being operated upon by Celsus, who lived during the period of 42 B. C. to 37 A. D., but history does not record any operation on palatal deformities until 1764 when La Monier, a French dentist, performed the operation.

There is no more prevalent misunderstanding of the functions of the various organs of the body than regarding those which enter into the production of speech. It is almost universally believed that the tongue is the principal organ of speech. On the contrary, while the tongue, lips, teeth, cheeks, vocal cords, pharynx and palate are all important vocal organs and do their part in clarifying enunciation, in the distinct articulation of consonant sounds, in the perfection of vocal resonance, the *palate* is supreme. In 1887, the late Dr. G. V. Black said: "There is a peculiar fact in connection with the phenomenon of cleft palate. We may cut away the lips, the teeth and the tongue and the patient may talk plainly after all, but if we cut away the soft palate, it seems to be utterly impossible for the patient to speak perfectly."

To corroborate the above, I quote from the late Dr. G. Hudson-Makuen: "The vowel sounds may be articulated when the palate is defective, but their resonance is so much impaired that they are scarcely recognizable and their pitch cannot be changed with any degree of accuracy. It is in the articulation of consonant sounds, however, that the palate is especially essential.

"Of the twenty-three consonant sounds, only two, the "m" and "n", can be given intelligibly when the palate is not intact, and even in these the resonance is somewhat impaired. All those consonant sounds in the enunciation of which the tongue is a conspicuous factor, as s, z, t, d, l, etc., as well as those in which the lips and

teeth are used—the p, b, w, f, etc., are impossible to a person with a defective palate. This is true because, in the enunciation of these sounds, the palate is necessary to confine the breath to the oral channel and to prevent it from passing up through the nasal chambers.

"It will be borne in mind that the consonant sounds are made by impeding the moving column of breath at certain points above the larynx. The points at which the impediment takes place have been called the stop positions. These have been divided into the anterior, the middle and the posterior stop positions. * * * For all these sounds requiring an impediment in the outgoing column of breath, whichever stop position may be used, it is necessary to have a freely movable and normal palate.

"The soft palate has a wide range of movement. Its function in vocalization is to assist in controlling the action of the vocal cords and regulating the size and shape of certain important resonance chambers, and its function in articulation is to shut off the nasal from the oral cavity during the emission of the explosive and fricative sounds, and to form contacts with the tongue in the formation of the so-called posterior linguo-palatal sounds." Again he says: "Not only are the tongue contacts important, but in the production of many of the consonants there is a damming up, so to speak, of the breath in the mouth and a slight explosive effort as the sound is emitted. When this takes place in the normal mouth, the velum rises and shuts off completely the oral from the nasal cavities, and this is one of the things which the velum of a cleft palate cannot do and which it must be made to do before we can get the best results from the standpoint of speech. The velum of a cleft palate, therefore, must be united in such a manner that it will be as large and as loose as possible with its muscles in their normal positions and relations, and then the patient should be given such exercises as will have a tendency to develop in these muscles their normal physiological functions."

A thorough understanding, not only of the importance of speech, but of its mechanism is most essential to suc-

cess in palatal surgery. The surgeon must have always in mind the goal of correct speech and he must know how that speech is attained by normal organs so that he may use every means to conserve and build up a normal mechanism from the defective parts which he finds in a cleft palate.

All surgery of cleft palate should have for its ultimate object perfect function, which is perfect speech. The test of success is the quality of enunciation resulting. Two phases of palatal surgery have especially to do with this: the union of the separated bones of the palate, including the management of the premaxillae; and the control of the tuberosities in their relation to the soft palate. Without a proper conception and execution of these fundamentals in palatal surgery, there is small hope of securing satisfactory form or function. I wish today to emphasize the control of the tuberosities.

I present to you briefly the course which I am convinced gives the nearest approach to normal form and function in the palate. That course provides for operation in early infancy; it contemplates the establishment of a normal palatal arch and the prevention of the spreading of the tuberosities; it calls for three stages in the treatment of typical double cleft of the lip and palate, and sometimes four, if complicated by protruding premaxillae. These stages are as follows:

1st. The freshening, approximation and immobilization of the cleft bones so that union may take place.

2nd. The closure of the lip.

3rd. Operation upon the soft palate.

4th. Elevating the nose which may have become flattened by the moving backward of the premaxillae.

The first step should be taken as soon after birth as expedient,—the 4th to 10th week, or after the functions of the body have become well established.

The second step, the closing of the lip, should be done in from 6 to 10 weeks after the union of the bones.

The third step, the closing of the soft palate, should be deferred until just before speech is attempted, usually about the 18th month.

The fourth step is to elevate the nose, if necessary.

The progressive surgeon no longer waits until a child is from 3 to 12 years of age before operating, or after bad habits of speech have been acquired, but now agreement is fairly general as to the wisdom of early operations. Closing the lip first, depending upon the traction of the orbicularis oris muscle to approximate the bones, or passing a single wire through the anterior part of the separated maxillae and bringing them together thus, cannot produce the best results.

The closing of the lip and the resultant traction of the orbicularis oris muscle *will* gradually move the anterior part of the cleft bones into contact, but the bones will not, as a rule, be normally approximated nor united. The bone carrying the premaxillae protrudes beyond the maxilla of the opposite side, leaving an ugly malformation of the nose and arch. Besides, there cannot be union of the bones with the muco-periosteum intervening. They only meet, remain malposed and leave the patient deformed throughout life.

I have time here only to say, with regard to the premaxillae, that they should always be preserved and utilized to maintain the normal dental arch, the facial contour and the full complement of teeth. They should *never* be excised, for an irreparable deformity is the unfailing result.

SPREADING OF THE TUBEROSITIES

I have spoken of the closing of the lip first, as a means of approximating the separated bones of the palate. When the anterior part of the cleft is brought together by the lip traction plan or by the single wire, the surgeon fails to give consideration to the consequent separation of the bones posteriorly. Every surgeon experienced in this work realizes that oftentimes these bones are widely separated posteriorly, due to the moving together of the anterior part of the cleft and the action of the muscles; and they cannot assume a normal position unless measures are employed to overcome this separation. With muscular force applied anteriorly and with no restraining force posteriorly, the maxillae act as levers, the malar processes becoming the fulcra; and as the anterior ends

of the maxillae are drawn together the posterior ends, aided by the upward pressure of the mandible, move apart.

Unless steps are taken in early infancy to prevent the tuberosities from spreading (which is accomplished by the use of wires not only anteriorly but posteriorly), the bones will separate widely and the palate will be shortened to such an extent that perfect speech will seldom be secured. When the tuberosities are abnormally separated the soft palate, when united, will be put on the stretch and consequently shortened so that it cannot reach the post-pharyngeal wall; it will be like a drumhead, without flexibility or resilience. If lateral incisions are made through the soft palate in an attempt to relieve tension, a great mass of cicatricial tissue will result which makes it thick, unwieldly and inflexible.

The horizontal plates of the palate bones are elevated; the tuberosities are widely separated; consequently the hemispheres of the soft palate are also widely separated. The soft palate may be to some extent atrophied for want of normal use, but the width of the cleft is not due so much to atrophy as to the malposition of the parts.

It must be remembered that lateral incisions oftentimes divide the fibers of the tensor palati-muscle, which has a two-fold function—to make tension on the palate and to dilate the pharyngeal orifice of the Eustachian tube. The division of this muscle leads to early defective hearing, due to the destruction of the continuity of the muscle and consequent failure of the normal dilation of the pharyngeal orifice of the Eustachian tube. When introducing the posterior wire in operating on the soft palate, it should be passed as nearly as possible through the center of the tensor palati muscle as it swings around the hamular process, thus suspending the contraction of the muscle until the hemispheres of the palate unite.

I regret that I have not time to discuss the treatment of the defective lip and nose, for this phase of plastic surgery is most important in rounding out the work of making normal these patients who come in such distressing condition. But what does it avail, to produce the most careful and painstaking operation on the lip, if under-

neath there is an improper foundation for this superstructure? There must be first provided a normal, well-rounded arch upon which to build a well shaped lip, and there must be a normal position of the tuberosities of the maxillae in order that a flexible, resilient soft palate may be produced, to carry out this "New principle essential to correct speech in the treatment of complete congenital cleft palate."

PAPERS ON PSYCHOLOGY AND EDUCATION

RELATION OF QUICKNESS OF LEARNING AND RETENTIVENESS

H. A. Peterson, Illinois State Normal University, Normal

From many different points of view educators are working to individualize teaching. Investigations of individual differences in learning abilities and in retentiveness of learners should result in differentiating the length of the study period for different members of a class, and the amount and frequency of reviews needed to fix permanently in mind what has been learned. Educational and psychological tests have furnished innumerable curves showing the distribution of learning abilities in a homogeneous group of learners, but apprehension is only half the story. Retention must be secured. What is the relation of speed of learning to retentiveness?

Norsworthy, Pyle, Lyon, and others have studied the relation of the rate of learning to retentiveness. They agree that those who learn quickly retain a larger number of units than those who learn slowly, and in some cases, as large a proportion of what has been learned, as those who learn slowly. Lyon finds some exceptions to the last statement. In the case of meaningful material (prose or poetry) the quick learners sometimes retain an even larger percentage of what they learn than the slow learners, while in the case of mechanical material, such as numbers, the quick learners do not retain as large a percentage of their gains as the slow learners do of theirs.

The present investigation is confined to one kind of subject-matter, prose, and goes beyond the results of the investigators mentioned: first, by using longer selections; secondly, by using larger groups of subjects; and, thirdly, by attempting to define more precisely the relation of rate of learning to the amount retained. Another purpose was to ascertain whether the material is suitable for use as laboratory experiments for college classes.

To a normal school class of 56 students a geographical selection of 250 words was given in mimeograph form.

It described the character of the Philippine Islands and people. The first five lines will suffice as a sample:

(1) The Filipinos as a race are not vicious. / (2) Their common crimes are rather slight offenses, such as the theft of articles of small value. / (3) Gambling is perhaps the chief vice, / (4) and a Filipino will risk his last penny on a cock fight / (5) or a horse race./ (6) Americans are apt to think the Filipinos are lazy. / (7) This is partly true. / (8) For centuries they have learn-

The numbers and the oblique lines were not on the learning sheets, and are inserted here merely to aid in explaining the methods of grading employed later. The students were given two and one-half minutes in which to study the selection, and then reproduced as much of it as they could in their own language immediately and again a week later. The first is taken as a measure of what was learned; the second, as a measure of what was retained. The learning was with knowledge that the reproductions would be called for.

The selection was then divided into 36 "facts" or ideas, as shown by the numbers and oblique lines in the sample above, and the ratio of the number of facts which each retained to the number which he had learned was found. This is called the percentage of retention. The group was then arranged in the order of the number of units learned, and divided into quartiles. The results for the different quartiles follow. The figures in the second and third columns give the average number of facts learned and retained respectively. The fourth column gives the average ratios of retention to learning by quartiles:

RATIOS OF RETENTION TO LEARNING IN THE FIRST SELECTION

Rank of quarters	Av. learning score	Av. retention score	Av. p'c't. retained	Standard deviation
1	25.5	22.2	88%	3.6
2	19.1	15.3	80	6.0
3	14.9	12.7	85	5.3
4	9.1	7.9	88	5.5
Avs.	17.1	14.5	85	5.1

In general the four quartiles retained about the same percentage of what they had learned, viz., from 80 to

88%. Inasmuch as the quartile which learned the most learned about two and one-half times as much as the quartile which learned the least, the advantage is clearly and decidedly with the more rapid learners. If it be thought that the differences in the retention ratios of the quartiles is significant, the idea is soon dispelled, for repeating the experiment five times, each time with a new group, showed very small average deviations for each quartile from the average of all 24 ratios. The average of all the ratios is 82; the average deviations of the four quartiles from this average is +2.3 for the first quartile, —0.3 for the second, 0 for the third, and —0.8 for the fourth.

With the same group of subjects a much more difficult selection, "The Policies of Labor Unions," was next tried. It dealt with the theory of labor unionism, and was taken from Readings in Economics by C. J. Bullock. It contained about 900 words. The first ten lines of the selection used are:

Collective Bargaining. 1. *Its purpose.* If the whole body of workers of a given kind can be brought into the union, so that the union can meet the employers as the representative of the whole, the position of the worker will be greatly strengthened. The fear that if he refuses to accept certain terms, another man will be employed in his place is removed. His ignorance of the market conditions will be partly remedied both thru the combination of the knowledge of all the workers of the union, and in some cases, by the broader outlook which the union officials, partly or wholly exempted from daily application to manual work, may be able to obtain. The whole matter of bargaining can be put into the hands of the most—

Two changes were made in method. First, on account of the greater length of the selection, the subjects answered questions about it instead of reproducing it. Secondly, each subject determined his own length of learning time, knowing that the length of the time he took was an element in determining his score. The learning scores and retention scores of different subjects were made comparable by calculating the amount learned and

the amount retained per minute of time invested in learning by each subject. A summary of the results follows: The figures in the second column give the average learning scores of the quartiles. If all the questions had been answered correctly, the score would have been 100%. The figures in the third column give the average retention scores after one week; those in the fourth column, the average learning times in minutes. The figures in the fifth and sixth columns give the average learning and retention scores per minute of time spent in learning (M. L. T.), and those in the seventh column give the average percentages of retention.

RATIOS OF RETENTION TO LEARNING IN THE SECOND SELECTION

Quarters.	Av. learning score	Av. retention score	Av. time	Av. L. S. per M. L. T.	Av. R. S. per M. L. T.	Av. p'c't retained	Stand. dev.
1	74%	68%	9.5	7.8%	7.1%	91%	11.5
2	57	47	10.5	5.4	4.5	83	11.7
3	40	37	12.2	3.3	3.1	94	25.3
4	21	20	12.9	1.6	1.5	94	28.4
Avs.	48	43	11.3	4.5	4.0	90	19.2

The quartile which learned the most took the least time for study. So far as quartile averages go, the higher the learning ability the less time needed for study, in spite of the greater gains from study. With the increase in the difficulty of the material the range between the best and the poorest learners increases. Whereas in the first selection the fastest quartile learned two and one-half times as much as the slowest, in the second selection the fastest quartile learned nearly five times as much as the slowest. The second selection was intentionally somewhat difficult for the class. An idea of how difficult it was may be gained from the fact that the average mark of the whole class in learning was 48%, 100% being a perfect answering of all questions. We are most interested in the percentages of retention, however. The first, third, and fourth quartiles retain about the same percents, 91, 94, and 94; the second quartile retains 83%. The standard deviations are large in the two slowest quartiles because when a person learns very little, an ability to answer one question more or less greatly changes the ratio of retention to learning.

The correlations between learning and retention, based on the absolute numbers of units, i.e., numbers of "facts" in the first selection, and percentile marks in the second selection, are very high. For the first selection the correlation is .87±.02, and for the second selection, .94±.01. Lyon's correlations are much lower, "seldom going above .4 and averaging only .25"[1] when prose was used as the material, and recall without any re-learning was the method employed. His method of measuring quickness of learning was not as exact as the method here employed. He used the amount of time needed to secure a perfect recital, and when a subject failed to give a perfect recital, he was obliged to resume learning, and this time was of course added to the learning time.

Summarizing our results we may say that differences in the rate of learning between the best and the poorest in a group increase with increase in the difficulty of the subject matter. By difficulty is meant thought difficulty. In this investigation at least it is true that when persons are allowed to determine the length of their learning time, or time spent in study, those who learn the most take the least time. Concerning the relation of retention to learning, there is a decided tendency in this investigation for fast and slow learners to retain about the same proportion of what they learned, and this is true whether they reproduce what they learned in their own language, or answer questions on it, and whether the subject matter is easy or difficult. Lastly, the material is very well suited for laboratory experiments in educational psychology.

Some corollaries for teaching practice are, that teachers should ascertain the relative learning abilities of their students early and assist them to become conscious of their rates of learning, and to adapt the length of their study periods to their abilities, or else teachers must expect less of the slower learners. Secondly, in class reviewing fast learners can review their larger learning in about the same time as slower learners review their smaller learning, and with equal effectiveness.

[1] Lyon, D. O. Relation of Quickness of Learning to Retentiveness, p. 49.

THE ABILITY OF MEN AND WOMEN TO JUDGE INTELLIGENCE

L. W. Webb, Northwestern University

The problem investigated in this study is the relative values of the judgments of men and women in rating the intelligence of the same people.

There were one hundred four students in one of my classes, fifty-three men and fifty-one women. The names were printed and sent to the faculty with the following instructions:

"Consider all the students whom you know. Divide them into ten groups basing your judgment upon their intellectual ability; the students of the highest ability to be in group ten, the next highest in group nine, and so on to the poorest students who will be in group one. Will you look over the following list of students; in the column, *Rank,* place opposite each student's name the number from ten to one according to which group you think he belongs as per the ten relative intellectual groups mentioned above."

The students employed the same method in judging the intelligence of one another. The purpose of the project was fully explained to the students and they were urged to rate only those students who were well known to them.

Three intelligence tests were given to the students: Army Alpha and two tests devised by Thurstone labeled A and B. The complete scholastic record of each student was secured from the Registrar's office. Fifty members of the faculty rated the students. However, only eighty-two students were judged by the faculty while ninety-seven were rated by the students. Forty-one men and forty-one women were rated by the faculty. The men students judged thirty-two women as against fifty men; women passed judgment on the intelligence of forty-four women and thirty-five men. The rating of no student was used unless he was graded by at least three people. The range of the number of judgments on each student was, in the case of the faculty, 3 to 15, while that of the students was from 3 to 68; the average number of ratings per student in the former instance was 6; in the

TABLE I.

Men's Judgment of Men Versus Women's Judgment of Men

	1	2	3	4	5	6	7	8
	Men of men	Women of men	Faculty of men	Sch. of men	A	B	A B	Alpha
Average...	65	70	63	63	52	63	57	46
Range....	45–87	41–87	39–94	43–95	33–82	39–94	41–81	13–85
A. D.....	7.33	8.26	11.42	11.35	9.00	11.42	9.57	19.81
S. D.....	9.70	10.68	12.93	13.66	11.15	12.92	11.29	22.91
Q. D.....	9.25	8.50	12.00	11.75	8.25	12.00	10.25	20.50

TABLE II

Men's Judgments of Women Versus Women's Judgments of Women

	1	2	3	4	5	6	7	8
	Men of women	Women of women	Faculty of women	Sch. of women	A	B	A B	Alpha
Average..	72	69	68	70	53	69	62	54
Range....	40–90	40–97	35–93	46–96	29–81	42–96	37–87	16–94
A. D.....	8.48	10.42	10.46	10.82	8.23	13.60	10.00	16.00
S. D.....	11.08	13.02	13.58	13.38	10.89	15.15	12.30	18.85
Q. D.....	9.00	10.50	13.50	13.50	7.50	14.75	9.62	16.75

latter case 27. The range of the number of women rating men was 3 to 38; when judging women it was from 3 to 40. The average in the first case was 13.9, while in the latter instance it was 18.8. The average number of judgments of the men when rating men was 18, the range 3 to 37; when they rated women the range was 3 to 29 and the average 13.4. The results of this study are presented in four tables given above.

In Table I. the ability of men and women to judge the intelligence of men is compared. According to our rating scale numbers from 10 to 100 are obtained. All the other scores with which the judgments are compared were reduced to a similar basis in order to facilitate comparison. In this table the average of the judgments of the men and women are given together with the range, A. D. S. D., and Q. D. The results of the faculty judgments of men are presented, also the scholarship record and the score of men in tests A, B, average of A and B, and Army Alpha.

It will be noted that the judgments of the women run slightly higher than do those of the men. The same results obtained when the women's ratings were compared with the other average. The variability of the score of the men and women is slightly less than is any of the other instances. This is probably due to the fact that there is a larger number of figures combined in case of men than in any of the other columns.

Table II. compares the judgments of men and women passed upon the intelligence of women. In this instance it is discovered that the men tend to rate the women higher by only a very small margin. The differences in this table are not so marked as those in Table I.

When the results in the two tables are compared it is observed that women tend to rate men higher while men show a partiality in judging women. Their judgments of women are higher than they are of men. Women placed a slightly higher value on the intelligence of the men than they did upon that of women. Columns three to eight in Table II., which are the records for the women, are somewhat higher than the corresponding columns in Table I, which are the scores of men.

The second method by which these data were studied is that of correlation.

In Table III. are given the Correlation values of the judgments of men and women of men, when compared with the various criteria. The correlation values are arranged somewhat in groups; the first group has to do with the Thurstone Tests, the second gives the results when using the Army Alpha test scores; and the third group shows the correlation values with scholarship and faculty judgments. The values in the first two groups were also averaged.

With the Thurstone test, women have higher correlation values in three of the four cases of comparison. The ten values obtained by using Army Alpha show the women to have a higher correlation in five instances, lower in two, and practically the same in three instances of comparison. In the last group, the men show higher correlations for both items. Considering the entire sixteen correlations, the women have 8 higher; the men 5.

TABLE III

Correlation of Men's and Women's Judgments of Men with Various Criteria

	Men of men	Women of men
Thurstone A	.350 ± .084	.335 ± .102
B	.310 ± .087	.411 ± .096
A + B	.340 ± .085	.402 ± .097
Average	.33	.382
Army Alpha 1	.077 ± .098	.307 ± .104
2	.423 ± .080	.422 ± .093
3	.407 ± .082	.450 ± .092
4	.477 ± .075	.444 ± .092
5	.200 ± .095	.028 ± .115
6	.126 ± .097	.206 ± .100
7	.395 ± .074	.394 ± .097
8	.047 ± .099	.134 ± .113
Total	.410 ± .083	.419 ± .095
Average	.284	.312
Scholarship	.587 ± .063	.536 ± .081
Faculty judgments	.687 ± .058	.665 ± .072
Average of all	.346	.360

The range of the differences for the men is from 2 to 18, four being between 2 and 5. This makes an average difference for the men of 6 points. The range of the differences in favor of the women is from 3 to 23; two of the differences are 3, two 5, three between 6 and 9, one 10 and one 23. The average difference in favor of the women is 8.61. Of the 28 correlations, exclusive of the averages, 21 are sufficiently high to be of some significance. The values of greatest significance are those obtained when correlation is made with scholarship and faculty judgments.

In Table IV. the relationship between men and women's judgments of women and the several criteria are considered. The same criteria are used here as were employed in Table III, and the values are grouped in the same manner as in the preceding table.

By observing the data of this table it will be noted that in all 14 cases of comparison the women have higher values. The differences in favor of the women range from 15 to 46, with an average of .322. All of these dif-

ferences are large enough to be significant. The average of the three correlations obtained when Thurstone's Test was employed shows a difference of 35 points in favor of the women. In regard to the average of the nine r's of Army Alpha, there is a difference of 30 on the side of the women. When all the correlation values are averaged the women obtain an advantage of .259.

In the column of the woman's judgments, all of the values are of some significance; 4 are between .266 and .372; 3 between .401 and .467; 3 between .545 and .597; 4 are between 60 and 70. Ten of the 14 values are sufficiently high to be quite significant. The average of the

TABLE IV

Correlation of Men's and Women's Judgments of Women with Various Criteria

	Men of women	Women of women
Thurstone A	.245 ± .110	.467 ± .081
B	.265 ± .109	.639 ± .061
A + B	.201 ± .112	.660 ± .058
Average	.233	.588
Army Alpha 1	.116 ± .113	.300 ± .095
2	.130 ± .114	.372 ± .091
3	.073 ± .115	.445 ± .084
4	.147 ± .112	.545 ± .073
5	.054 ± .116	.401 ± .088
6	.114 ± .112	.266 ± .097
7	.014 ± .117	.283 ± .096
8	.231 ± .081	.597 ± .067
Total	.218 ± .104	.597 ± .067
Average	.121	.422
Scholarship	.280 ± .106	.704 ± .051
Faculty judgments	.281 ± .117	.619 ± .069
Average of all	.162	.421

14 r's is .421. None of the 14 correlation values obtained for the men's judgments of women are of any significance. The highest value is only .281 while the lowest is .014. The average of all 14 values is .162. In no instance is the r three times the size of the P. E.

With the foregoing data as the basis, the following conclusions are justified:

1. No significant difference appears in the judgments of the two groups in terms of the central tendency.

2. Each group shows some partiality to the opposite sex in estimating its intelligence; that is, the men give evidence of placing a slightly higher value on the intelligence of women than they do that of men. The women appear to do the same thing in regard to the men. This partiality is not striking.

3. The type of intelligence that this group of people rated should probably be termed scholastic intelligence. Three of the four correlation values in Tables III. and IV. having to do with scholarship are sufficiently high to be significant. Scholarship is not the important factor in determining men's judgments of women. The only instance where higher values are found is when the faculty ratings were used as a criterion for correlation purposes. In another study the correlation between faculty judgments of intelligence and scholarship was found to be .760.

4. When the intelligence of men is estimated, the two groups manifested about equal ability. If there is any difference at all, it is in favor of the women. However, the difference is not sufficiently large to be of any significance.

5. The women evidenced a decided superiority in judging the intelligence of women; practically all the correlation values were high enough to be of significance.

6. The men's ratings of the women were practically worthless. In no instance was a significant correlation found.

The practical outcome of this study is that when men are to be judged by a rating scale, either men or women could be used as judges. However, when women are to be rated it would appear to be wiser to employ women as judges.

TACTUAL INTERPRETATION OF ORAL SPEECH

ROBERT GAULT, NORTHWESTERN UNIVERSITY

In a paper read before the American Psychological Association a year and more ago I stated that a subject in our laboratory at Northwestern University had learned to recognize seven spoken words when he had no criteria to go by excepting the vibrations of the speaker's vocal apparatus conducted through an air column in a tube 14 feet long to the palm of the subject's hand. In May, 1923, I added a footnote to the paper when proof was being corrected for the Journal of Abnormal Phychology and Social Psychology, saying that up to that time 34 words had been learned, together with a great number of sentences made up of those words in various combinations. In fact he was able to get the sense of any such sentence. Furthermore, he had learned to distinguish high and low tones provided there was a difference of an octave at least between them. This result was obtained in the course of 78 periods, one a day. Actual practice never occupied more than 35 minutes at a sitting.

The subject in this case was a normal hearing young man, a sophomore in the University. The situation was so arranged that he could not hear. The speaking tube I have referred to extended through two walls and the intervening room. At the subject's end it terminated in a double pine box, the outside dimensions of which are 2 by 2 by 2½ feet approximately. The space between the outer and the inner wall, five inches deep, is packed with cotton waste. At the front end of the box is an aperture surrounded by a rubber collar.

The subject thrusts his hand through the aperture and holds his palm closely over the end of the tube. In this position the rubber collar grips the forearm and the whole apparatus is, for our purposes, sound proof. Additional precautions against hearing were introduced as follows:—First, the experimenter muffled his face in a feather cushion and spoke through a narrow aperture in it into a funnel upon his end of the tube. Second, the subject plugged his ears with soft putty and cotton batting, covered his ears with a heavy bandage, and kept an

electric motor humming at his side. Even without these precautions it was impossible for any one of about twenty-five students and for several disinterested visitors who are competent critics of experimental work to hear what was going on.

Visual stimuli were employed as aids whenever a new word was being added to the tactual vocabulary. When the subject saw the word "Ray", for example, displayed upon a card, he knew that the next tactual impressions upon his palm would be such as arise from speaking that word into the tube. The visual tactual connection was repeated as often as necessary to establish the association, and new words were added as rapidly as possible.

At the end of the academic year the subject had attained an accuracy of from 88% to 95% in the recognition of 200 word impressions. (Each word in the vocabulary repeated several times.)

Up to this time practice had been only with the right hand. On the last day of April, which was the last day of practice, the left hand was employed as the right one had been used theretofore, and recognition proved to be quite as accurate as with the other hand. This result suggests that we are not dealing here with an absolute increase in sensitivity but with a control of attention directed toward small differences in tactual stimulation. On the same day we made another crucial test at the suggestion of Professor McDougall. A list of eight monosyllabic words was prepared upon no one of which the subject had practised. He recognized six of the eight. This indicates, I believe, that the vowel sounds in these words had become isolated in the course of the development of the vocabulary of 34 words, even though no specific attempt had been made in that direction.

Four months after the last test in April, 1923, after a summer of no practice, the subject was tested again by the method with which he had become familiar. On this day he recognized 71% of the 200 tactual stimuli: a loss of 30.5% on the basis of his maximum record in April. The stimuli and method employed in this test were those that were in use on the last day of practice in April.

The query has been raised in some quarters whether the subject in these experiments has not the advantage of bone conduction. I think not, for the following reasons:

(1) The tactual stimuli are so slight that it is inconceivable that they can escape being absorbed by the cushions of flesh in the palm and in cartilage in the joints intervening between the palm and the brain center.

(2) The subject persistently denies that his experience is auditory. This he could not do if bone conduction were a fact.

(3) If bone conduction were involved the subject would not be compelled to learn the meaning of the impression more than you have to learn the meaning of the impressions you receive when the receiver of your telephone is held against your chest. But there has been learning and it was a tedious process.

I am indebted to Mr. George Crane, Assistant in our department, for indispensable aid in conducting this experiment, and to his brother, John Crane, for having given his time as a subject without academic credit.

In view of our success with the speaking tube it occurred to us to substitute for it an acousticon device such as is used for the aid of the partially deaf. It is well known that if one holds the ear piece of such a device in the hand, one can sense its vibration occasioned by the speaker's voice, against the transmitter at a distance. The question is: "Can a subject learn to interpret these vibrations against the skin in a situation in which hearing is out of the question?"

Through the generosity of the Dictograph Products Corporation of New York City, we were provided at the close of the last academic year, and repeatedly since, with the necessary apparatus.

It was our expectation to begin experimentation with the present year, following essentially the same method as that which proved successful last year, but with two modifications:

(1) Stimulation should be applied not to the palm, but directly to the tip of a finger resting lightly against the diaphragm of the receiver.

(2) Instead of employing isolated words as stimuli to be later framed into sentences, we would begin with sentences forthwith and later arrive at isolated words and their phonetic elements. We should thus parallel an approved method of teaching reading.

On October 29, the subject who succeeded with the speaking tube last year was tried out, without previous drill upon the acousticon. He recognized 58 out of 100 impressions, the stimuli being selected from among those with which he had become familiar last year.

The experimenter and the subject in work with the acousticon are separated by from 30 to 60 feet. The receiver lies within the sound-proof box, and the subject's hand, grasping it, is enclosed as in the earlier experiments. The additional precautions against hearing, already described, are employed in this case also.

In preliminary experiments in which the writer was subject, four short sentences were used as stimuli:

Jack did like teacher.
Henry did not begin.
He did like work.
Say, did Jack accept?

No well-defined principles led to the choice of these sentences. Many others would have served as well. They contain a considerable variety of vowel values. It was our expectation that, after considerable practice, these vowel values would begin to emerge in the tactual sense.

Work began with the fourth week in October. The tip of the index finger of the subject's left hand was held lightly against the diaphragm of the receiver. Practice was had four days each week, extending over from 45 to 90 minutes daily. Owing to limitations due to other engagements on the part of experimenter and subject, it was impossible to distribute the time in an ideal manner, as is required by the law of distribution of time in the chapter on learning.

At each sitting, for purposes of drill, the experimenter pronounced the four sentences into the transmitter in an order known to the subject, ten times in succession. The same sentences were then pronounced in orders not

known to the subject during the remainder of the day's period of experiments. Notes were compared after each reading of the four sentences.

After two weeks—eight sessions—the subject had attained an average accuracy of approximately 70% on the four sentences, each of which was presented 50 times. The fourth sentence he recognized in 86% of cases. It began to be apparent to the subject, however, that up to this time his criteria of judgment were tempo, emphasis, number of syllables in a sentence—not the quality of the stimulations. We therefore framed new sentences, using the old words, to test the question whether any more intrinsic quality of the words was beginning. The result was disappointing. Previous practice had given the subject no noticeable advantage in learning the new word groupings.

The subject then began holding the receiver with the aperture disclosing the diaphragm toward the palm. In this case the vibration of the diaphragm is conducted through a cushion of air to the palm and the tactual area stimulated is less restricted than in the earlier practice. By this method, in six sittings the subject attained a confident mastery of the four original sentences and the new ones. These trials carried us up to the end of the first week in the present month.

Up to that time we had drawn the conclusion that success in the interpretation of tactual stimuli arising from oral speech will depend upon the stimulation of a fairly wide area or pattern of tactual organs.

On December 10, we began practice upon the long vowel sounds and continued through the 11th and 12th. We spent approximately one hour on each of these days at drill alone. The order of presentation was always known to the subject, and in the course of every period each vowel was presented 30 times, or 90 times during the three days. Our method of procedure from the 13th to the 19th, inclusive, was as follows:

(1) The experimenter recited the vowels five times in a known order.

(2) He recited 15 series of unknown order, 10 in each series (each vowel occurring twice), the subject writing

down what vowel each impression seemed to him to represent.

(3) The subject and experimenter checked up and the experimenter repeated the series for drill.

(4) After this a new unknown series was presented.

Beginning with the 20th each vowel in the series of 10 was pronounced three times instead of once. Otherwise the method remained the same as before. This modification of procedure is apparently producing good results.

Experience up-to-date satisfies me that it is possible to learn to interpret oral speech by tactual impressions.

I have not yet made a learning curve for each vowel. **I** is most easily learned with **A** and **O** close seconds. **E** and **U** are easily confused. As nearly as I can describe the criteria they are as follows:

A is a long, heavy, steady impression.

E is long and steady, but not so heavy as **A**.

I gives two impressions. The first is quick and sharp. The second is prolonged, rather heavy and smooth.

O has a roll about it that may be mistaken for two distinct impressions such as **I** affords.

U is short, light, and smooth.

A SERIES OF STUDIES ON THE RELATIVE VALUE OF PSYCHOLOGICAL TESTS AND TEACHERS' JUDGMENTS AS A BASIS FOR MEASURING PUPIL MENTAL ABILITY

F. E. Clerk

New Trier Township High School
Kenilworth

INTRODUCTION

No single factor in education in recent years has been so widely heralded as the panacea for so many of our educational ills as psychological and standardized tests and measurements, and perhaps no single factor ever came into widely accepted use in public education with quite the same degree of apparent justification for dependability and validity. The very origin and development of these tests seemed to be a guarantee that they would do all that even the most enthusiastic of their proponents claimed for them. Arising as they did under scientific auspices, further developed according to the best of scientific educational procedure, it seemed that there was little else to do but accept them as a part of regular school practice and make the best possible use of the results.

Many school systems throughout the country have adopted the use of some of the now over two hundred and seventy different varieties of tests in their classrooms, and some school systems have gone even so far as to use them exclusively as a basis for classifying, grading and promoting individual school children and judging the quality of the teaching and the effectiveness of the school supervision. This practice presents a problem of which it is the purpose of this study to attempt to find at least a partial solution. The problem involved is concerned with the reliability of the average teacher's judgment of the mental ability of his pupils, as compared with the use of standardized tests for the same purpose. It is not accepted as a proven thesis, as far as this paper is concerned, that "Intelligence" should be the sole basis for classifying, grading or promoting pupils,

though it seems so to be used in many school systems. It is assumed that intelligence plays a very important role among the factors that should determine the classifying, grading and promoting of pupils, and that in order to place pupils in the school system where they will probably make the best progress of which they are capable, it is necesary to know, among other things, all that it is possible to know about their intelligence.

We recognize that traditionally the teachers' judgment, often expressed in very vague terms, was the only basis used in classifying, grading and promoting pupils. That these judgments were often mistaken will probably be first admitted by the teachers themselves. There are many reasons why teachers' judgments are not infallible. In the first place, they are personal and individual judgments, the validity of which must vary according to the ability of the teachers to judge. In the second place, the judgments of the teachers are being applied to the most difficult and complex of all phenomena, i.e., mental capacities, whose nature is so complex that the most searching study must be made of each pupil before one can be reasonably sure of one's judgment. In the third place, teachers' judgments of pupils' mental capacities are, by the very nature of their situation, largely determined by the accomplishment of the pupils in school studies, limiting the judgment, therefore, to a special type of activity in a special environment. Accomplishment in any field is a resultant of many factors, such as interest, capacity, industry, health, etc. To say that mental ability, therefore, is measured by accomplishment in school work is true only in part. In the fourth place, it is inconsistent to measure children of differing degrees of maturity on the same basis, yet this is the common practice, chronological age seldom being taken into consideration. A ninety per cent achievement in a school subject by a child ten years of age means a mental capacity greater than the same degree of achievement by a thirteen year old child, yet it is the usual procedure among schools to apply a standard of achievement to a class regardless of the age of the children in it. An examination of the grading and promotion plans of pub-

lic school systems will indicate that this method is almost universally followed.

Economy of time, provision for individual differences, and other equally important considerations make it imperative that there shall soon be developed a reliable and ready means of measuring mental ability. There are at the present time two leading methods employed in different school systems for this purpose, viz., teachers' judgments and psychological tests, some using one exclusively, some using the other exclusively and some using both in varying degrees. It is the purpose of this paper to indicate the results of several different types of attempts to determine whether or not, under differing conditions, the two methods will produce the same or similar or different results. At this time, it cannot be said with sufficient assurance whether the intelligence tests or standardized subject tests or phychological tests or the teachers' judgment is the most reliable. Where the tests and the teachers' judgment agree we feel reasonably certain of our results; where they differ it remains a question as to which is correct.

A STUDY OF THE RESULTS OF AN ATTEMPT BY TEACHERS TO SEGREGATE PUPILS ON THE BASIS OF MENTAL ABILITY IN THREE GROUPS: ACCELERATED, NORMAL, AND RETARDED, AND THE RESULTS OF A SEGREGATION OF THE SCORES MADE BY THE SAME PUPILS ON THE OTIS TEST EXPRESSED IN INTELLIGENCE QUOTIENT EQUIVALENTS.

When the Winchester, Va., Public schools were reopened for the fall term in September, 1919, the teachers were asked to group the pupils in sections or classes as far as possible on the basis of mental ability, grouping the brighter pupils together, the average pupils together and the slower pupils together, whenever there were enough pupils to make three or more divisions. Allowing for the limited time given in preparation for this reorganization and the fact that the re-distribution was further complicated by a change from the old 7-4 plan to a 6-3-3 plan, we still find a considerable lack of agreement between the judgments of teachers as to pupil mental ability, and pupil mental ability as measured by the Otis Intelligence Tests.

Tables 1, 2, 3, 4, 5, 6, 7 and 8 indicate the distribution of chronological ages, mental ages and total scores in the Otis Intelligence Tests, and the equivalents in Intelligence Quotients in grades seven to nine inclusive after the pupils had been distributed into groups according to mental ability as determined by the teachers' judgment. (In this connection account must be taken of the fact that about twenty pupils, or approximately 6% of the total number of pupils, could not be placed as recommended by the teachers because of program complications.)

This was done only in grades seven, eight and nine.

Table 1 consists of a group of pupils that were considered bright or accelerated by the teachers who judged them. The Otis test shows a range of mental ability in this group from I. Q. 33 to I. Q. 130 with a median of I. Q. 103. Seven pupils, or sixteen per cent of the group, have an I. Q. below 80 while only thirteen pupils, or thirty-three per cent of the total, are clearly in the accelerated class as measured on an I. Q. basis only. The other Tables show equally striking differences between Intelligence as measured by the teachers' judgment and as measured by the Otis Test. The summary shown in Table 8 presents further evidence of a lack of conformity between the results of these two methods of measurement, e.g., in the normal group ninth grade we find a range in I. Q. including 157, which is higher than any I. Q. in any of the accelerated groups. In the seventh grade accelerated group we have an I. Q. of 33 which is clearly a feeble-minded score. Aside from individual discrepancies in scores, which may be regarded as exceptions or may be explained by circumstances not revealed by the test, we find the median of the only retarded group greater than the medians of two of the three normal groups and almost equal to the median of the third normal group.

It must be considered at this point that the seventh and ninth grade normal groups contain all the slow or retarded pupils in those grades, not enough in number, however, to make the difference indicated in the distribution as determined by the judgment of the teacher. As

a result of this study, it appeared that the correlation between these two measures of mental ability was very low. After these results were brought to the attention of the teachers, it appeared that the teachers' judgments were mistaken in about as many instances as it was demonstrated that, because of other personal qualities such as perseverance, concentration, industry, "the will to do", etc., or a lack of these and similar qualities, a pupil was better able to work with a group above or below his mental ability. After a redistribution of the pupils considering *both* the teachers' judgments and the intelligence tests, we found that about ten per cent of the pupils of an accelerated group would be composed of pupils below the I. Q. limits for the group, but able to do the work of the group because of personal qualities not measured by the intelligence test but observed by the teacher. In normal groups twenty per cent were below the I. Q. limits of the group for the same reason, and ten per cent were above for reasons of indifference, laziness, over-confidence and similar qualities. In the retarded groups two per cent were found whose I. Q. would indicate that they belonged to the accelerated group and twenty-five per cent to the normal group. As far as this study is conclusive, then, it appears that these measures of ability cannot safely be used separately but that they can be used together with a reasonable degree of assurance.

A STUDY OF THE SCORES MADE BY A SPECIAL GROUP OF FIRST GRADE PUPILS ON THE DEARBORN GROUP INTELLIGENCE TESTS, THE SPECIAL GROUP OF PUPILS HAVING BEEN SELECTED BY THEIR TEACHERS AS AVERAGE CHILDREN OR BELONGING TO THE MIDDLE FIFTH OF THEIR RESPECTIVE CLASSES IN MENTAL ABILITY.

In further preparation for the reorganization of the Winchester, Va., schools on a basis that would provide for accelerated normal and retarded children, group intelligence tests were given to all pupils in grades one to eight. The total number of tests given was seven, no pupil receiving less than three different group intelligence tests. For convenience they are designated here

as G-1, G-2, G-3, G-4, G-5, G-6, G-7. Of these G-1, G-2, G-3 were tests which, with some changes and additions, now constitute Series I of the Dearborn Group Tests of Intelligence.[1] G-4, G-5, and G-6 included parts of several standard psychological tests, several tests now a part of Series II of the Dearborn Group Tests of Intelligence,[1] and certain other psychological tests developed in the Harvard Psychological Laboratory. G-7 was one of the Alpha Tests of the Army Psychological Examination. All of these tests were standardized and graduated according to the plan indicated below, wherein are chosen the grades in which each test was given.

Grade	Tests given							
1	G-1	G-2	G-3					
2	G-1	G-2	G-3					
3	G-1	G-2	G-3	G-4				
4	G-1	G-2	G-3	G-4	G-5			
5				G-4	G-5	G-6		
6				G-4	G-5	G-6	G-7	
7					G-5	G-6	G-7	
8					G-5	G-6	G-7	

Each pupil was given three or more different intelligence tests, to avoid, as far as possible, the contingency that a chance failure or success in any one test might misrepresent the pupil's true capacity. Such a contingency was further avoided by the fact that in most cases each test was given on a different day, that the dangers of an "off day" might be lessened. To avoid the difficulties usually encountered when pupils of widely differing degrees of maturity and of widely differing degrees of education are tested by the same materials, different tests were given to pupils of different grades, but those tests so overlap that comparison and correlation are possible throughout with known relations between the different tests..

As a basis for obtaining some data on the possible correlation between a teacher's judgment of mental ability and the results of these tests, the teachers in grade one were asked to make a list of all their pupils whom they would designate as of average mentality, i. e., falling in the middle fifth of their classes. When these lists were received a comparison was made with the list con-

[1] These tests are now published by the J. B. Lippincott Company, Philadelphia.

taining the names and scores on tests G-1 and G-2 from the testing program described above of these same first grade pupils. Table 9 indicates the results of this comparison. It is to be read as follows: Twelve pupils, or 26.7% of the total number of first grade pupils, who were judged by their teachers to belong to the middle fifth of their classes, or in other words who were judged by their teachers to be of average mentality, received scores on test G-1 indicating that they belonged to the lowest fifth of the class. In test G-2 there were eight pupils, or 17.8 per cent, who were judged to be average by the teachers, who were measured by the test as in the lowest fifth. In the middle fifth where we might expect a high percentage of agreement, if there was a high degree of correlation between these methods of measurement, we find a low percentage, 17.8 and 28.8. In other words, as far as this experiment goes, it appears that those pupils, who are judged by the teacher to be of average mentality, have about an equal chance of making a score on these intelligence tests that would place them in any fifth of the class.

As between these two methods of determining mental ability, there is no correlation in this case. Evidently the teachers were not measuring the same thing that the test was supposed to have measured, or, if either method is an adequate measure of mental ability, it cannot be said with confidence that it functioned in this attempt. There are a number of factors that would easily explain the inadequacy of either the test or the teacher in this case. The tests were new tests and not fully developed, they were given to first grade children, the teachers had had these children only two months, the school system in which the test was made was entering upon a period of reorganization, and the teachers, though experienced, were not well trained. Any one of these factors would be sufficient to discount the results, unless they were under control (which they were not) or were verified by other similar experiments and studies.

A STUDY OF THE DISTRIBUTION OF INTELLIGENCE QUOTIENTS OF A GROUP OF PUPILS AS DETERMINED BY A TRAINED EXAMINER WORKING WITH THE BINET-SIMON TEST (STANFORD REVISION) AND THE JUDGMENTS OF THE TEACHERS OF THE SAME PUPILS IN ALLOCATING THEM ON A BASIS OF MENTAL ABILITY TO A QUINTILE IN THEIR RESPECTIVE CLASSES.

In a further attempt to study the relative merit of the judgments of teachers as a basis for measuring pupil mental ability, an experiment was organized in which an effort was made to protect the validity of the results by every possible precaution that our experience, up to this time, would suggest. The results of this study are tabulated in Table 10. These ratings were prepared by teachers who were asked to indicate in which fifth of their respective classes they would place certain pupils who had previously been tested individually by a trained examiner with the Binet-Simon (Stanford Revision) Scale. The teachers, not being informed of the scores made by the pupils tested, were asked in which fifth of the class from "E", the lowest, to "A", the highest, these pupils would be classified in "intelligence".

The distribution of the ratings indicate a considerable discrepancy between the judgment of the teacher and the results of the tests. For example, eleven pupils were shown by the Stanford-Binet Intelligence Tests to have an I.Q. between 61 and 65, a rating that would indicate probable feeble-mindedness or a near moron condition. Three of these pupils were rated by a teacher in the lowest fifth of their classes, three were rated in the next to the lowest fifth, three in the middle fifth, one in next to the highest fifth and one in the highest fifth. Similarly, of twenty pupils whose scores in the Binet Tests indicated a status of slow-mindedness (I.Q. 81 to 85), two were rated as belonging to the lowest fifth of the class, four in the next lowest fifth, seven in the middle fifth, five in next to the highest fifth and two in the highest fifth, i.e., more than one-third of the pupils who, according to the Binet Tests, were rated as "slow", were rated by the teacher as "above the average".

Equally lacking in correlation is the case of the group of seventeen in all, whose I.Q.'s fell between 96 and 105, i.e., the normal group. Only three of these were rated by teachers as belonging to the middle fifth of their classes, five were rated as belonging to either the lowest or next to the lowest fifth of the class, and nine were placed in either the highest or next to the highest fifth of the class. In the case of two pupils who made a very high score that fell between 126-130 in the Binet Test, one was rated as belonging to the highest fifth of his class and the other was rated as belonging to the lowest fifth of his class.

The lack of correlation in the instances noted above between the judgments of teachers and the Stanford Revision of the Binet-Simon Test for intelligence indicate that in this instance, at least, doubt may be reasonably expressed on the reliability of either the results of the tests or the judgments of the teachers.

A STUDY OF TEACHERS' JUDGMENTS AFFECTING ALL THE PUPILS FROM GRADES ONE TO TWELVE INCLUSIVE, EXPRESSED IN TERMS OF INDUSTRY, SCHOLARSHIP AND INTELLIGENCE, AND THE DISTRIBUTION OF THE PUPILS IN TERMS OF INTELLIGENCE TESTS EXPRESSED IN INTELLIGENCE QUOTIENTS.

Our study so far seems to indicate that there is little or no correlation between the judgments of teachers and intelligence tests, when applied to pupil mental ability. Since either one or the other or both must be justified, and since it appears that in the process of judging so far a number of teachers have asked to have "mental ability" defined, it was decided to extend the study and organize it so as to direct the attention of teachers to intelligence as differentiated from other qualities often confused with it in the attempt to form a judgment. In this study the Intelligence Quotients were obtained in the first and second grades by the Stanford-Binet Tests; in the other grades, three to twelve inclusive, they were computed from the results obtained by giving the Otis Intelligence Tests in grades seven to twelve and the Dearborn Tests in grades three to six. The teachers' at-

tention was directed to "intelligence" in such a manner as to differentiate it from "industry" and "scholarship".

In preparation for this attempt to compare the judgments of teachers in determining intelligence with the results obtained from Intelligence Tests, written instructions were distributed to each teacher as follows:

November, 1921.

DIRECTIONS TO TEACHERS

Follow these directions exactly:

1. In the place indicated write the first and last names of each pupil being tested.
2. Under "Age" give the exact present age in years and months, as 8-3.
3. School Grade. Write 1, 2, 3, 4, etc., showing present school grade of pupil. Indicate grade exactly, including group, e. g., 1A, 2B, 4C, etc.
4. Years in school. Write 3, 4, 5, etc., to indicate the exact length of the time pupil has been in school, from the time he first entered school to the end of the school year June, 1921. Indicate in years only, not years and months.
5. Ratings by Teachers. These ratings are to be made on a five point scale, as follows:
   A means superior, about the score of the best 5 per cent of children of that race* and age in public schools.
   B means high average, above the average, but not as good as A. About 20 per cent of the children make this score.
   C means average, the score of the middle 50 per cent of that race and age in the public schools.
   D low average, means below the best 75 per cent of school children of that race and age, i. e., below the middle 50 per cent, but not as poor as the lowest 5 per cent.
   E means inferior, about the score of the poorest 5 per cent of the children of that race and age in the public schools.

QUALITIES

a. *Scholarship.* In rating a pupil in scholarship, think about how well he does in his school studies. If he is average, mark him C. If he is good as the best 5 per cent of children you have known in the public schools, mark him A. If he is better than the poorest 75 per cent of the public school children you know, but not as good as the best 5 per cent, mark him B. If he is poorer than the best 75 per cent you have known, i. e., poorer than the middle 50 per cent, but not as poor as the poorest 5 per cent, mark him D. If he is as poor as the poorest 5 per cent of children in the public schools, mark him E. Proceed similarly with every other child on the list. Compare him with school children generally, not only with those in his own group.

b. *Intelligence.* Intelligence is not the same as scholarship. In scoring pupils for intelligence, think of the skill with which they are able to meet new situations, both in school and out. It is not always true that the most intelligent pupil makes the highest marks in school, nor that the pupil with the highest marks in

* Colored children were in separate schools.

school subjects is the most intelligent child. An intelligent child may earn high school marks if he is industrious, if he is physically well, if he is regular in attendance and if all other school conditions are favorable. If these conditions do not maintain he may still be intelligent and not earn high marks. Proceed in estimating the intelligence by the same method as used in estimating scholarship, scoring each pupil A, B, C, D, or E as indicated.

c. *Industry.* In rating a pupil for industry, consider his ability to apply himself to his school work, both in school and out, to learn his lessons and to do other set tasks, as far as this may be known to you. Proceed as in the case of scholarship and intelligence and score each pupil A, B, C, D, or E as indicated.

The form (Appendix A) was supplied to each teacher with the copy of the directions. Where there were different ratings for the factors of "Intelligence", "industry" and "scholarship", as actually appeared in sixty-three per cent of the cases, it was evident that in the mind of the teacher there was a difference between these elements that are often considered under one head as a basis for promoting or for estimating pupil mental ability.

In order that the teachers might not be influenced by giving too definite consideration to any one of the three qualities to be rated, the purpose of this expression of judgment was not made known to them. With these precautions it is reasonable to assume that we have as accurate an expression of the ability of these particular teachers to judge the intelligence of their pupils as it is possible to get. It is also to be observed, in connection with this effort to determine the relation between these methods of measuring pupil mental ability, that most of the teachers have now had two years' experience with the use of intelligence tests and an organized effort to judge pupil mental ability in connection with the tests. It is also to be observed that the pupils being judged in this study were allocated in groups known as accelerated, normal and retarded, which fact would have its effect as a general guide to the teachers in making their estimates and would in turn be modified by the fact that a pupil in the first fifth of a retarded group would in all probability not be judged as in the first fifth of an accelerated group. In making our comparisons this latter fact has been provided for by segregating the reports of the estimates of the teachers by groups as the pupils actually appeared in

the classrooms. Tables 11, 12 and 13 reveal the results of this attempt on the part of the teachers to estimate or judge the mentality of their pupils allocated in groups according to mental ability, the mental ability groups having already been determined by a combination of other teachers' judgments and an intelligence test.

Table 11 should be read as follows: In all the accelerated classes (11 in number) there were two pupils whose I. Q. ranged from 60-69 who were judged by their teachers to be equal in intelligence to the middle fifth of their classes (both these pupils were judged in the highest fifth in "industry" and "scholarship"). Of all the pupils in the accelerated classes, there were fourteen pupils whose I. Q. ranged from 70 to 79. One of these was judged by his teacher to be of an intelligence equal to the lowest fifth of his class, three as belonging to the next to the lowest fifth, five as belonging in the average fifth, two next to the highest fifth and three in the highest fifth. The three judged to be in the highest fifth were also judged to be in the highest fifth in "industry", the two in next to the highest fifth were also judged to be in the highest fifth in "industry" and "scholarship". It is also significant to note, on the other hand, that of the two pupils whose I. Q.'s are over 149, one was judged by the teacher as in next to the highest fifth in "scholarship" and in the average group in "industry"; the other was judged to be in the first fifth in "scholarship", the first fifth in "industry", but was given a mark of "A—" in "Intelligence". (No provision had been made for an "A—" rating; it was the teacher's method of drawing attention to the fact that this pupil's intelligence was of a quality inferior to his "industry" and "scholarship".)

In Table 12 a similar explanation is found in the detailed reports of the unusual ratings shown in the Table; for example, the one pupil whose I. Q. is given as within the range of 50-59 and was judged by his teacher to be in the average fifth of his class in "scholarship" and in the highest fifth of his class in "industry". Of the ten pupils, whose I. Q.'s were within the range of 120-129, seven were judged to be in the next to the lowest fifth in

"industry", and three in the lowest fifth. All ten were judged to be in next to the highest fifth in "scholarship".

An analysis of Table 13 with the detailed reports of the teachers shows similar explanations for nearly all of the exceptional ratings varying in degree from only slight explanations to full explanations. For example, the one pupil, whose I. Q. is given as within the range of 120-129 and who was judged by his teacher to be in the average fifth of his class in "intelligence" and in next to the upper fifth in "industry" and in the average fifth in "scholarship", is either an anomaly, or a teacher has made a mistake in judgment, or he does not have the I. Q. indicated by the test. A number of instances, equal to eleven per cent of the total number similar to this one, have been found. They represent roughly the extent of the failure of the combined use of the teachers' judgments and intelligence tests in allocating pupils. These pupils are either misplaced or have been properly placed because of circumstances not revealed by the elements discussed in this study.

Our previous attempts to determine the relation between the use of intelligence tests as a method for measuring "intelligence" and the value of a teacher's judgment for this purpose indicated that there was only a slight correlation between the two methods. The number of individual variations in the two methods did not justify the statement that there was a close or even a fair correlation between them. The attempt just described, however, shows that there is a very close correlation between the two methods, when "intelligence" has been differentiated from other factors, such as "scholarship" and "industry". In our previous studies we were comparing the results of a measurement of intelligence only, with a measurement of intelligence plus industry, scholarship and other personal factors. We were comparing methods of measurements that could not be compared because they did not measure the same things. Our latest effort, however, indicates that the teacher's judgment and the intelligence test are comparable when applied to the same factors and that they do correlate to a high degree.

Tables 14, 15, 16, 17 and 18 indicate the distribution of all the pupils in the school, allocated on the basis of mental ability as determined by the intelligence tests and mental ability plus other significant factors as determined by the teachers' judgments. It is noted that there is a group of pupils, between the I. Q. range of 60 to 120, some of whom are in the retarded group, some in the normal group and some in the accelerated group. In a strict segregation into groups on an I. Q. basis alone, this would not happen, but where the judgment of the teacher is used as a partial basis for segregation the result is an overlapping of the groups as far as the I. Q. is concerned, due to the fact that the teacher observes certain facts about the pupils that the intelligence test does not reveal, and these facts are significant enough to make it wise to place some pupils in groups above their I. Q. rating and some below.

As far as intelligence is concerned, some pupils who might do well in an accelerated group apparently do only well enough to hold a place in a retarded group and conversely some, who, as far as intelligence is concerned, might be in the retarded group, are able (because of other personal qualities) to hold a place in an accelerated group. It seems obvious then, that while the intelligence test is reliable as an approximate measure of the mentality of groups of pupils, the teacher's judgment is indispensable to a more detailed and exact study of the group and of the individuals within the group. In other words, the results of the tests must be interpreted in the light of the teacher's judgment and not be held for the measurement of factors which they were not intended to measure.

CONCLUSIONS

1. Intelligence Tests should not be held responsible for testing anything but that for which they have been designed to test.
2. In judging intelligence only, care must be taken to differentiate it from other qualities.
3. The results of intelligence are, as far as scholarship is concerned, very much the same as the results of industry.

4. It is possible for a pupil with a high degree of intelligence and a low degree of industry to be outclassed by a pupil of a low or average degree of intelligence and a high degree of industry.

5. Teachers' judgments are essential to a proper interpretation of tests for determining the intelligence of their pupils where an attempt is made to segregate pupils on an ability basis.

6. Generally teachers' judgments and the results of intelligence tests do not correlate. This is true because generally a teacher's judgment of intelligence includes some other factors.

7. As a supplement to the judgments of teachers in the process of promoting and allocating pupils, intelligence tests intelligently given and interpreted are of very great value. To a school system where an attempt is made to allocate pupils on a basis of mental ability, they are indispensable.

TABLE I

GRADE 7A

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and Intelligence Quotient Equivalents. Selected on basis of teachers' judgment as bright or accelerated pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	15-11	5-3	7	33
B	15-3	9-2	54	64
C	13-1	9-3	55	71
D	13-8	10-9	73	79
E	13-7	10-9	73	79
F	12-0	11-1	77	92
G	13-2	11-2	78	85
H	12-6	11-3	79	90
I	13-1	11-4	80	87
J	12-3	11-4	80	92
K	15-3	11-4	80	74
L	12-6	11-7	83	92
M	15-0	11-9	85	72
N	14-1	12-5	93	88
O	13 9	12-9	97	93
P	14-8	12-9	97	87
Q	14-5	12-10	98	91
R	13-1	12-11	99	98
S	12-4	13-0	100	105
T	12-7	13-2	102	104
U	11-7	13-2	102	123
V	13-2	13-3	103	100
W	15-7	13-3	103	100
X	13-6	13-3	103	106
Y	12-8	13-7	107	107
Z	11-11	13-8	108	115
a	12-1	13-8	108	113
b	12-10	13-10	110	108
c	12-2	14-2	114	116
d	13-1	14-3	115	109
e	12-3	14-7	119	119
f	14-2	14-8	120	104
g	13-0	14-8	120	113
h	12-4	14-9	121	119
i	14-2	14-10	132	105
j	13-0	15-0	124	111
k	13-4	15-0	124	113
l	12-2	15-1	125	124
m	14-8	15-2	126	97
n	13-7	15-2	126	112
o	12-9	16-3	139	128
p	14-2	17-4	152	122
Minimum	11-7	5-3	7	33
Median	13-1	13-3	103	103
Maximum	15-11	17-4	152	130

TABLE 2

GRADE 7B

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as average or normal pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	16-2	8-1	41	50
B	13-6	8-4	44	62
C	13-6	9-0	52	67
D	16-7	9-0	52	54
E	12-8	9-11	63	78
F	13-8	10-0	64	73
G	12-4	10-0	64	83
H	12-11	10-2	66	79
I	13-6	10-5	69	77
J	15-0	10-6	70	70
K	14-0	10-8	72	76
L	13-11	10-11	75	78
M	16-5	11-3	79	71
N	13-7	11-3	79	83
O	13-11	11-3	79	81
P	12-3	11-6	82	94
Q	14-6	11-8	84	80
R	12-4	12-1	89	98
S	16-5	12-1	89	68
T	14-3	12-5	93	87
U	16-3	12-5	93	76
V	12-11	12-6	94	97
W	12-8	12-7	95	99
X	13-9	12-7	95	91
Y	15-2	12-9	97	84
Z	12-5	12-11	99	104
a	14-1	12-11	99	92
b	15-3	13-2	102	92
c	13-0	13-3	103	102
d	15-5	13-3	103	86
e	15-10	13-4	104	84
f	14-3	13-4	104	94
g	13-11	13-5	105	96
h	15-10	13-5	105	88
i	15-0	13-5	105	89
j	13-0	14-2	114	109
k	13-9	14-4	116	104
Minimum	12-3	8-1	41	50
Median	13-11	12-1	89	84
Maximum	16-7	14-4	116	109

TABLE 3

GRADE 8A

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as bright or accelerated pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	14-0	10-10	74	77
B	16-6	11-5	81	64
C	14-3	11-10	86	77
D	13-6	12-3	91	91
E	13-8	12-7	95	92
F	14-3	13-0	100	91
G	14-3	13-1	101	92
H	14-4	13-8	108	95
I	14-11	13-8	108	92
J	13-8	14-0	112	102
K	14-7	14-0	112	97
L	13-0	14-3	115	110
M	14-0	14-4	116	102
N	13-9	14-5	117	105
O	13-1	14-9	121	113
P	13-8	14-9	121	108
Q	14-1	14-11	123	105
R	13-9	15-2	126	110
S	11-5	15-5	129	135
T	13-7	15-7	131	115
U	14-6	15-7	131	107
V	13-9	15-9	133	115
W	14-11	15-11	135	107
X	15-1	16-1	137	107
Y	12-5	16-1	137	130
Z	12-9	16-1	137	126
a	14-9	16-2	138	110
b	14-4	16-4	140	114
c	14-9	16-5	141	111
d	14-6	17-0	148	117
e	12-10	17-1	149	133
f	14-2	17-6	154	124
g	15-7	17-7	155	112
h	14-10	17-11	159	121
Minimum	11-5	10-10	74	64
Median	14-2	15-2	126	107
Maximum	16-6	17-11	159	135

TABLE 4

GRADE 8B

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as average or normal pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	17-9	9-7	71	59
B	19-2	9-7	71	55
C	16-5	11-3	79	68
D	15-2	11-9	85	78
E	15-2	11-10	86	78
F	14-6	12-5	94	96
G	13-1	12-6	94	96
H	14-4	12-8	96	89
I	14-6	12-8	96	88
J	15-2	12-10	98	84
K	17-11	13-4	104	78
L	15-11	13-4	104	89
M	12-8	13-6	106	106
N	14-10	13-7	107	91
O	13-5	13-8	108	102
P	15-1	13-8	108	90
Q	14-3	13-10	110	97
R	13-8	13-11	111	102
S	14-10	14-5	117	97
T	13-8	14-8	120	107
U	15-11	15-0	124	94
V	18-0	15-7	131	87
W	15-5	15-8	132	102
X	13-7	15-9	133	115
Y	11-9	15-10	134	134
Z	13-7	16-0	136	111
a	16-2	16-2	138	100
b	14-8	17-6	154	120
c	13-7	17-6	154	129
d	15-5	17-11	159	116
e	12-7	18-7	167	148
Minimum	11-9	9-7	71	55
Median	14-10	13-8	108	96
Maximum	19-2	18-7	167	148

TABLE 5

GRADE 8C

Distribution of chronological ages, mental ages, total scores (Otis Intelligence Test) and intelligence quotient equivalents. Selected on basis of teachers' judgment as slow or retarded pupils.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	17-8	8-4	44	47
B	16-7	9-4	56	51
C	16-6	9-6	58	58
D	16-2	9-11	63	61
E	15-1	10-9	73	71
F	18-9	11-0	76	54
G	16-6	11-4	80	63
H	13-8	11-6	82	77
I	17-6	11-7	83	61
J	14-9	12-4	92	84
K	14-7	12-6	94	86
L	16-9	12-7	95	75
M	16-4	12-8	96	78
N	16-4	12-10	98	79
O	14-11	12-10	98	88
P	15-2	12-11	99	85
Q	14-4	13-2	102	92
R	15-4	13-5	105	87
S	16-9	13-6	106	81
T	14-4	13-11	111	97
U	14-6	14-1	113	97
V	12-1	14-4	116	117
W	15-8	14-5	117	94
X	13-2	14-6	118	110
Y	13-6	14.8	120	109
Z	13-9	14-8	120	107
a	15-8	14-8	120	94
b	15-6	14-10	122	96
c	17-5	15-1	125	87
d	16-3	15-2	126	93
e	14-3	15-2	126	107
f	15-5	15-7	131	101
g	16-0	16-0	136	100
h	13-4	16-0	136	120
i	14-8	16-7	143	113
j	16-1	16-8	144	103
k	15-0	16-8	144	112
l	13-11	17-9	157	128
m	13-5	18-0	160	134
Minimum	12-1	8-4	44	47
Median	15-4	13-11	111	91
Maximum	18-9	18-0	160	134

TABLE 6

GRADE 9

Showing the distribution of chronological ages, mental ages, total scores (Otis Test) and intelligence quotient equivalents of all pupils in grade 9, (1920). These pupils are selected on the basis of a combination of the results in Otis intelligence tests and the teachers' judgment as the lower half of grade 7 (1918) to go on with Junior High 8th grade work, the upper half to be known as grade 9, effecting the change from the 7-4 plan to the 6-3-3 plan. For distribution in upper half of grade 7, (1918) see table 7, being grade 10 (1920).

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	16-9	10-4	66	61
B	16-7	11-8	74	72
C	17-6	11-10	86	67
D	14-2	11-11	87	84
E	15-11	12-0	88	75
F	17-3	12-9	97	74
G	15-5	13-1	101	85
H	17-5	13-3	103	76
I	16-0	13-3	103	83
J	15-11	13-3	103	83
K	14-3	13-4	104	94
L	15-7	13-6	106	87
M	14-1	13-6	106	96
N	17-11	13-7	107	76
O	16-6	13-9	109	83
P	14-10	13-9	109	93
Q	16-4	13-11	111	85
R	17-5	14-2	114	81
S	13-10	14-2	114	102
T	15-9	14-3	115	91
U	14-8	14-5	117	98
V	14-1	14-5	117	102
W	16-2	14-7	119	90
X	18-6	14-7	119	79
Y	15-4	14-9	121	96
Z	16-5	14-10	122	91
a	15-11	14-10	122	93
b	17-5	14-11	123	85
c	18-11	15-0	124	79
d	13-7	15-1	125	111
e	15-4	15-2	126	99
f	16-3	15-2	126	94
g	16-10	15-3	127	91
h	16-4	15-7	131	95
i	17-6	15-8	132	90
j	14-9	15-9	133	107
k	17-5	16-8	144	96
l	12-2	19-1	173	157
Minimum	12-2	10-4	66	61
Median	16-1	14-3	115	90
Maximum	18-11	19-1	173	157

TABLE 7

GRADE 10

Showing distribution of chronological ages, mental ages, total scores (Otis Test) and intelligence quotient equivalents of all pupils in grade 10, being same pupils as were selected as upper half of grade 7 (1918) to go on with high school work to be known as grade 9 (1919), grade 10 (1920) etc.

Pupil's name	Chron. age	Mental age	Test score	Intelligence quotient
A	19-6	12-3	91	63
B	15-2	13-1	101	86
C	16-7	13-3	103	76
D	16-5	13-9	109	88
E	17-11	14-6	118	81
F	13-1	15-0	124	115
G	17-2	15-3	127	84
H	16-5	15-3	127	92
I	16-2	15-3	127	94
J	13-11	15-3	127	115
K	15-3	15-3	127	100
L	16-0	15-4	128	96
M	14-9	15-6	130	105
N	18-4	15-8	132	85
O	15-0	15-9	133	105
P	15-5	15-10	134	102
Q	16-0	16-0	136	100
R	16-10	16-0	136	95
S	14-10	16-1	137	108
T	17-4	16-2	138	93
U	15-4	16-2	138	105
V	15-11	16-3	139	102
W	15-1	16-3	139	107
X	15-1	16-3	139	107
Y	13-7	16-5	141	121
Z	18-8	16-8	144	89
a	14-7	16-9	145	115
b	18-10	16-11	147	90
c	13-7	17-5	153	128
d	15-2	17-5	153	115
e	15-1	17-5	153	115
f	13-8	17-6	154	129
g	16-2	17-7	155	109
h	15-3	17-10	158	117
i	17-2	18-0	160	105
j	14-10	18-1	161	121
k	16-8	18-2	162	109
l	16-2	18-2	162	112
m	13-4	18-3	163	137
n	14-4	18-6	166	129
o	14-10	19-7	179	131
p	15-11	20-5	189	128
Minimum	13-1	12-3	91	63
Median	15-5	16-3	139	105
Maximum	19-6	20-5	189	137

TABLE 8

Grade	Accelerated		Normal		Retarded	
7	Minimum I. Q.	33	Minimum I. Q.	50	No group	
	Maximum I. Q.	130	Maximum I. Q.	109		
	Median I. Q.	103	Median I. Q.	84		
8	Minimum I. Q.	64	Minimum I. Q.	55	Minimum I. Q.	47
	Maximum I. Q.	135	Maximum I. Q.	148	Maximum I. Q.	134
	Median I. Q.	107	Median I. Q.	96	Median I. Q.	91
9	Minimum I. Q.	63	Minimum I. Q.	61	No group	
	Maximum I. Q.	137	Maximum I. Q.	157		
	Median I. Q.	105	Median I. Q.	90		

Summary of tables 1, 2, 3, 4, 5, 6, 7, showing minimum, maximum, and median intelligence quotients of pupils selected by teachers as belonging to either accelerated, normal or retarded groups.

TABLE 9

Showing the scores on * Test G-1 and on Test G-2 received by first grade pupils who were judged by the teachers to be of average intelligence—receiving grade C by teachers.

	Numbers whose scores indicated intelligence that of					
	Lowest fifth *	2d fifth	Middle fifth	4th fifth	Highest fifth	Total
Test G-1 (numbers).....	12	9	9	9	7	45
Test G-2 (numbers).....	8	6	13	8	10	45
Test G-1 (per-cent).....	26.7	20.0	17.8	20.0	15.5	100.0
Test G-2 (per-cent).....	17.8	13.3	28.9	17.8	22.2	100.0

* Series I Dearborn Group Tests of Intelligence.

* TABLE 10

Showing the correlation between (a) the intelligence of pupils as measured by the Stanford-Binet Intelligence Tests, given in terms of the Intelligence Quotient (I. Q.) and (b) the teachers' judgments concerning the pupils' intelligence, (given from E lowest to A highest). 130 cases.

Read as follows:

Of pupils having intelligence quotients between .50 and .55, two were judged by teachers to be in the lowest fifth of their classes, in intelligence. Of pupils having intelligence quotients between .56 and .60 one was judged by the teacher to belong in the lowest fifth of the class and one was judged by the teacher to belong in the next to the highest fifth. Of eleven pupils who had intelligence quotients between .61 and .65 three were judged to belong to the lowest fifth, three to belong to the next to the lowest fifth, three were judged to belong to the

* Educational and Psychological Tests in the Public Schools of Winchester, Va., University of Virginia Record Vol. 6, No. 6, January, 1922.

middle fifth, one was judged to belong to the next to the highest fifth, and one was judged to belong to the highest fifth.

Intelligence quotient	Teachers' judgments					
	E	D	C	B	A	Total
50–55	2	..	..	..	..	2
56–60	1	..	..	1	..	2
61–65	3	3	3	1	1	11
66–70	1	5	2	..	..	8
71–75	2	7	3	1	..	13
76–80	3	4	4	..	..	11
81–85	2	4	7	5	2	20
86–90	1	5	3	3	..	12
91–95	1	4	2	1	1	9
96–100	1	3	2	5	2	13
101–105	..	1	1	1	1	4
106–110	..	2	1	2	1	6
111–115	1	..	1	2	3	7
116–120	..	..	..	2	1	3
121–125	..	..	..	..	2	2
126–130	1	..	..	..	1	2
131–135	..	..	..	2	1	3
136–140	..	..	..	..	..	...
141–145	..	..	..	..	..	...
146–150	..	..	..	..	1	1
151–155	..	..	..	1	..	1
Totals	19	38	29	27	17	130

TABLE 11

A Comparison of an Allocation of ACCELERATED Pupils According to I. Q.'s and According to Teachers' Judgments

I. Q.	Number of pupils in					Total
	Lowest fifth of class	Next lowest fifth of class	Middle fifth of class	Next highest fifth of class	Highest fifth of class	
Below 50	0	0	0	0	0	0
50–59	0	0	0	0	0	0
60–69	0	0	2	0	0	2
70–79	1	3	5	2	3	14
80–89	0	7	20	15	4	46
90–99	0	5	27	31	14	77
100–109	0	2	36	54	13	105
110–119	1	4	30	34	21	90
120–129	0	0	5	24	14	43
130–139	0	0	3	6	10	19
140–149	0	0	0	2	4	6
Over 149	0	0	0	0	2	0
Totals	2	21	128	168	85	404

TABLE 12

A Comparison of an Allocation of NORMAL Pupils According to I. Q.'s and According to Teachers' Judgments

I. Q.	Number of pupils in					Total
	Lowest fifth of class	Next lowest fifth of class	Middle fifth of class	Next highest fifth of class	Highest fifth of class	
Below 50	0	0	0	0	0	0
50–59	0	0	1	0	0	1
60–69	0	6	6	2	0	14
70–79	1	11	22	7	0	41
80–89	1	18	55	25	0	99
90–99	2	14	60	26	3	105
100–109	0	8	36	21	3	68
110–119	0	3	10	9	3	25
120–129	0	0	2	5	3	10
130–139	0	0	0	0	0	0
140–149	0	0	0	0	0	0
Over 149	0	0	0	0	0	0
Totals	4	60	192	95	12	363

TABLE 13

A Comparison of an Allocation of RETARDED Pupils According to I. Q.'s and According to Teachers' Judgments

I. Q.	Number of pupils in					Total
	Lowest fifth of class	Next lowest fifth of class	Middle fifth of class	Next highest fifth of class	Highest fifth of class	
Below 50	3	2	5	4	0	14
50–59	3	12	5	2	0	22
60–69	4	13	7	3	0	27
70–79	9	35	32	4	0	80
80–89	3	41	38	2	0	84
90–99	0	15	17	10	0	42
100–109	0	6	15	2	0	23
110–119	0	0	3	2	0	5
120–129	0	0	1	0	0	1
130–139	0	0	0	0	0	0
140–149	0	0	0	0	0	0
Over 149	0	0	0	0	0	0
Totals	22	124	123	29	0	298

TEACHER'S ESTIMATE—PUPIL ABILITIES
November, 1921

Last Name, First Name	Age	Grade	Years in school	Scholarship	Intelligence	Industry

IS EDUCATIONAL RESEARCH YIELDING APPROPRIATE DIVIDENDS?

WALTER S. MONROE, UNIVERSITY OF ILLINOIS

It may perhaps appear suggestive of heresy to announce a title which raises the question of the value of educational research, but the experience of several years devoted largely to this field and my contacts with other investigators have convinced me that this is a question of vital importance. About ten years ago there began to be established in colleges and universities explicit organizations for the avowed purpose of conducting educational research. Several of these research organizations now enjoy liberal appropriations for this work. Somewhat similar research departments have been established in a number of public school systems. At the present time the number of such organizations in existence is probably one hundred. In addition there are a large number of workers who are carrying on educational research as personal projects. The Commonwealth Fund, General Educational Board, and other educational foundations are making generous donations to both individuals and research bureaus. The total annual expenditure for educational research is unknown, but undoubtedly it amounts to several hundred thousands of dollars.

The amount of educational research is also indicated by the large number of published reports. In the advance sheets of the biennial survey of education for 1920-22, a summary of certain phases of educational research for that period includes bibliographies totaling 518 titles. School surveys and mental tests are not included. Furthermore, it is announced that only the principal contributions are given in these bibliographies. Beginning in 1917, the Bureau of Educational Research at the University of Illinois has compiled a list of masters' and doctors' theses in Education. Although the compilations are not complete, as all the institutions have not reported their titles, 410 doctors' and 1896 masters' theses have been listed during a period of six years. All doctorial dissertations are expected to be significant contributions

to our knowledge about education. Many masters' theses make minor contributions.

What are the net results of all this activity? What additions have been made to our knowledge of education? What has been the effect of educational research upon school practice? Are we developing a group of competent and reliable research workers? Is the work being done increasing in quality as well as in amount? What has been the effect of educational research upon the attitude of teachers and of others not engaged in carrying on investigations? It would be presumptious for me to attempt a final answer to these questions, but a number of facts which have seemed significant and perhaps indicative of a general trend have recently come to my observation. Some of these facts I shall pass on to you with the hope that I may stimulate you to think about some vital questions. In the time at my disposal, I propose to cite illustrations of four sources of waste in educational research.

In a doctorial dissertation recently accepted and published by one of our foremost graduate departments in education, the investigator set for herself the problem of making an inventory of the content of the minds of children of six and seven years of mental age. Obviously the first step in dealing with this problem was to locate a representative group of children whose mental ages fell in the interval from six years and no months to seven years and eleven months. This was done by administering the Stanford Revision of the Binet Test to certain groups of children. Later they were given also the Herring Revision of the Binet Test. The average of the two measures was used as the criterion of mental age, although the results of the second test do not appear to have been used in determining what children should be chosen for the investigation. For reasons which are not made clear in the report, the investigator later administered four group intelligence tests and eleven specialized individual tests, and calculated from the scores thus obtained a number of coefficients of correlation and regression coefficients.

A careful reading of the monograph fails to reveal any use which was made of the additional data secured from these tests or of the derived measures which were calculated from the resulting scores. Two tables of coefficients of correlation are presented with the statement that the relations and inter-relations shown are "food for thought," but the report contains little or no evidence that the investigator made any effort to masticate or digest this "food." In fact, it is difficult for the reader to conceive how these correlations might have contributed to the study of the problem under consideration. One gets the impression that the giving of the tests and the subsequent calculations are for ornamentation rather than for any useful purpose. If one may be permitted to read between the lines, he might say that the investigator or her advisers believed that an acceptable doctorial dissertation must contain some coefficients of correlation and statistical formulae, and that in this case these features were added somewhat as an afterthought in order to meet these requirements. At least the reader cannot escape the conviction that the returns upon a certain portion of the investment in this investigation yielded only very meager returns if any at all.

It is not always possible for an investigator to estimate correctly in advance the value of all data collected, and of the calculations which he may make. There will necessarily be some scrapping of material in pioneer work, but this published report has been described as illustrative of a source of waste in educational research which unfortunately is more prevalent than seems to be justified. A careful definition of the problem and a strict adherence to the limitations of this definition will result in a mental reduction in the amount of useless data collected and tabulated.

The writer of a recent article gave a tabulation of the intelligence quotients derived from a group intelligence test. Several of the I. Q.'s were so low and others were so high as to suggest the presence of errors in the scores from which they were calculated. In the original article no mention had been made of this possibility, but a few months later a criticism was published in which the point

was made that the investigator should have considered these limitations in preparing his report of the study. In a reply the author of the original article criticised his critic. Among other things he said, "Nor can there be any question about the reliability of gathering the data. The tests were given by two experienced examiners and scored by trained scorers under supervision."

This statement expresses what appears to be a prevalent attitude toward the measures yielded by standardized educational tests. If the tests were administered by experienced examiners and if there is reason to believe that no errors were made in marking the test papers, then the scores may be considered accurate measures of the traits or abilities which the tests were designed to measure. If specifically interrogated, most test users would probably admit that our present standardized tests are imperfect, but a large number disregard possible limitations when they are using these instruments of educational research. Variable errors are always present in test scores and constant errors are frequently introduced even when the tests have been carefully administered. Critical studies of standardized tests have demonstrated that the possibility of errors in test scores is sufficiently great to make the investigator assume the responsibility for proving that his data are accurate when there is any reason for suspicion. Failure to do this means that the investigator is building upon a suspicious foundation which may result in the collapse of his conclusions. The conclusions reached by educational research cannot be more dependable than the weakest step in the study.

In view of the frequent failure of investigators to be critical of their data, it is then not inappropriate to raise again the question, "Are we receiving adequate dividends for the time and money which is being invested in educational research in the United States?"

There are literally hundreds of persons putting time and money in educational research, but with few exceptions they are working independently and with little reference to what other workers have already done. If one examines the voluminous literature in the field, he

will find relatively few attempts to summarize and organize previous contributions. As a result there are several sources of waste. Most of the educational research which has been done is fragmentary. The studies have been based upon too few cases, or have included only minor aspects of the problem, or have not been carried on long enough to lead to dependable conclusions. Because it is fragmentary much of this work will naturally be lost unless steps are taken to conserve it.

Cooperation has been urged as a means of coordinating and unifying educational research. Workers within certain areas have formed associations and provided facilities for exchanging information in regard to the problems which they are studying or which they expect to study sometime in the future. In this way they believe that duplication of effort can be avoided, or at least minimized, and that when two or more persons are engaged in studying the same problem or related problems, cooperation is mutually advantageous. Some leaders have taken the initiative in organizing those interested in a particular field into a cooperative group and have claimed that such pooling of abilities and resources will result in superior work.

In certain types of studies, cooperation in the form of assistance is necessary and in other cases it has doubtless been beneficial, but it will not correct certain wasteful tendencies. This can be accomplished only by changes in the attitude and interests of those engaged in educational research. Instead of emphasizing "original" research they must develop an interest in studying, in summarizing and in organizing the published reports of the work of others. In my experience with graduate students, I have found them much more eager to attempt an "original" study than to inquire into what has already been done. Recently I inquired of the departments offering graduate work in education concerning the types of theses which they urged students to undertake, or which they found most satisfactory. "Summaries of other investigations," were reported as being among the least satisfactory types of theses. On the other hand, the types most frequently mentioned as being encouraged,

or considered most satisfactory, included original investigations, surveys of a school system, or causal investigations. The popularity of such studies appears to be due to the ease with which they may be made; and the unpopularity of a summary of the work of others is due in part to the fact that such work is difficult and when well done requires a higher degree of ability. One of my correspondents made this illuminating statement, "According to present-day standards anything with tables and statistics seems to be most satisfactory. It is questionable, however, whether they really mean very much in most cases."

The prevailing attitude is reflected also in the preference for studies involving the use of a questionnaire, or of standardized tests rather than for those based upon data to be found in records or published sources. In far too many cases this preference is indicative of mental laziness. It is easy to ask questions for other people to answer. It is also easy to administer a standardized test. No particular ability or acquaintance with the field of education is required to do either of these things. Frequently I have received a number of questionnaires calling for information which was available in reasonably accessible published sources. These questionnaires have come not merely from graduate students who might have been unacquainted with the field, but in some cases from men who were acknowledged leaders and who have been identified with educational research for many years.

I do not wish to be understood as condemning the questionnaire as an instrument of research. Its use is inevitable for certain types of studies and there will always be occasions when a questionnaire will be appropriate, but I am citing the misuse of it as evidence of an undesirable attitude on the part of what I fear is a large number of persons. They seem to be most interested in doing something that will attract attention because of some special feature or of its newness rather than in making comprehensive and permanent contributions to our knowledge of education. Until there is a changed attitude with reference to the purpose and ideals of education research, and I am convinced that the responsibil-

ity for this change rests with those of us who are college teachers of education, most of our research will be fragmentary with resulting waste. As long as present conditions prevail we should ask ourselves, "Is educational research paying appropriate dividends upon its investment?"

When the proposal was first made that mooted questions relative to school practice could be answered by scientific methods, there were many unbelievers. For years the conservatives far outnumbered the progressives, but gradually the skeptics have been converted to the belief that educational experimentation is possible. Today these same people are among those who are accepting the fragmentary and imperfect findings of educational research as comprehensive and final. It is not at all unusual for a person who avows a belief in educational research to make dogmatic endorsements of the results of studies which meet few if any of the requirements of scientific procedure. For example, a teacher in a certain city school system recently asserted that the teachers of that system had solved the problem of constructing a curriculum in history. It was obvious that this teacher believed the work was finished and, because methods called scientific had been used, nothing more was to be said in the matter. This is not an isolated case, but unfortunately it is typical of the attitude of many toward educational research.

As I talk with superintendents and others, including university professors, who have not had intimate experience with educational research, I am surprised and distressed by their childlike faith in the conclusions based upon very imperfect studies. It appears that in our effort to convert those who hesitated to believe in educational research as a means of answering questions that we have overdone the matter. The possibilities of educational research have been advertised, and like all good advertisers we have extolled the good features and have failed to mention the limitations, or if mentioned we have suggested that they could easily be overcome. The result of our selling campaign begins to be apparent. In gen-

eral, educational research may be said to be sold to the public and to the greater majority of teachers and administrators, but educational research itself is failing to deliver the goods. There is being engendered a dogmatism which will exert a deadening influence upon our efforts to study educational problems scientifically. Again we may appropriately ask ourselves the question, "Is educational research yielding appropriate dividends upon its investment?"

This recital of waste in educational research might be greatly extended, but perhaps enough has been said to demonstrate that the title of my paper represents a very real question. There are those who are watching educational research to see what we make of it. Some day they will say, "What have you given in return for the generous investment which has been made in your work? Exactly what have you discovered about education?" They will expect an answer, not in terms of possibilities but of findings which may be considered as conclusive. They will not be satisfied with results that are merely fragmentary. When that day comes we shall need to be able to show that educational research has yielded and will continue to yield adequate dividends upon the investment. At the present time we may point with pride to certain notable achievements, and there is rapidly accumulating a commanding body of scientific information about education, but a few notable achievements will not be accepted as sufficient evidence that the present confidence and support of educational research should be continued. In closing, I command to your earnest consideration the question with which I started. A thoughtful reading of even a small portion of the published results of educational research will furnish much "food for thought."

PAPERS ON HIGH SCHOOL SCIENCE

THE ORGANIZATION OF A SCIENCE CLUB

RAYMOND LUSSENHOP, BOWEN HIGH SCHOOL, CHICAGO

The remarkable success of the Bowen Bird Boosters cannot be accounted for by the location of Bowen High School in the great Calumet district, where the students are accustomed to see smoke stacks instead of trees. To find the reasons for success, then, we must inspect the organization, the activities, and the policies of this science club.

Science teaches us accuracy, conciseness, and clearness. Why should its clubs not follow this trend? The purposes of this club are very plainly defined in the constitution, which states: "The objects for which this club are formed are: (1) to study birds; (2) to protect the birds; (3) to attract birds around our school, in our parks, and about our homes; (4) to subscribe for current bird literature and to support the Audubon Society both financially and with our influence".

"The officers of the club shall consist of a president, a vice-president, a secretary, and a treasurer." By an unwritten law, the president and the treasurer are always boys; the vice-president and the secretary are always girls. These officers are elected every spring. They must be members of the Zoology classes of that year and must be sophomores. The officers cannot be re-elected. This prevents a small group from getting and keeping control, a deadly mistake in any organization.

The membership is limited to those students who have taken or are taking bird study in the Zoology classes. At present the membership is 275. At the end of each year, all old members are dropped unless they retain their membership by the payment of their dues. For the first year the dues are 35 cents; for each year after the first, Juniors, 10 cents; Seniors, 5 cents. Seniors and Juniors taking Zoology are eligible for membership but not for holding office. Faculty members may be admitted to membership only on the recommendation of a student member of the club. The discussion and the vote on this prospective member must be held in secret, no member of the faculty remaining in the room while the students

discuss or vote on such a motion. Faculty membership is only honorary, as the voting privilege is withheld. We have 13 at present.

Of course, the most important activities of such clubs are their meetings. During the fall term, the Bowen Bird Boosters hold their meetings once a month; during the spring term, once every two weeks. The programs for these meetings are always posted a week in advance and are centered around a certain topic. For instance, a program will be centered around pigeons, or bird pests and their control; our game birds; migration, etc. At least two musical numbers are rendered but such numbers are always kept from being the most prominent part of the program. Every student taking part in the program must be a member of the club. This rule is inflexible.

Regular meetings are never allowed to become social gatherings; but an annual picnic held once every spring in some forest preserve, which can be reached by truck, is especially for fun. Our largest social affair, a fine program and dance, was given on our tenth anniversary. Even at this affair, attended by about 400 members, many belonging 10 years back, the program was entirely a student affair. The constitution does permit prominent men who are interested in birds to appear on programs, such as game wardens, museum workers, etc., men who are able to give interesting talks.

The policy kept in mind concerning programs is : (1) a program should never fail. If the program is made a farce, if the dignity of the occasion is forgotten for one moment, the program is a failure. It may amuse, it may even instruct, but its negative result is very serious, for each time a program falls through more students will lose interest and the club loyalty will lag; (2) all students scheduled for appearance must be present at the meeting and no excuses excepting those of sickness are accepted. In 10 years we have had but two failures to report; (3) to give real information. In order to obtain the best results, all reports are prepared under the guidance of the faculty adviser. Students in the first two years of high school have not, as a rule, had much training in outlining material. The faculty adviser sees that each student un-

derstands clearly his subject and that he knows which points are most important. In this way, the students gain confidence and can appear before the club with poise and dignity.

Another activity which deals directly with bird study is that of the bird identification lists. Three records are kept, the individual, the class, and the club. The individual record is kept by the student, on which he records all the birds he identifies on his bird hikes, or that he sees on his way to school. Spaces on these lists must be filled out as to the date, the bird's name, whether single or in flocks, place where seen, and what the bird is doing. The faculty adviser checks these lists from time to time, and corrects any mistakes. The class list is posted on a bulletin board, and if a student has identified ten birds, a red star is placed after his name; if 25, a silver star; if 50, a gold; if 100, a blue bird. This arouses enthusiasm in each class. On the third record which is furnished by the Illinois Audubon Society, the bird names are already printed with blank spaces in which the name and date of the first observer may be written. This arouses the keenest competition. These lists are of the most practical value in making the students familiar with our more common birds. For this work, the Reed bird guides are indispensable.

After careful analysis and consultation with some of our student members, I have come to the conclusion that the keystone of success of such a club does not rest so much in the organization or activities but in the wisdom of the relation of the faculty adviser and the faculty members to the students. In the first contact that students have with our club adviser the policy is clearly shown. When the incoming members begin their election campaign, no hints or suggestions are thrown out about who would make good officers, so that the students feel almost forced to elect the adviser's choice. Such a choice is left entirely to the students. Moreover, the faculty adviser promises to work cheerfully with their choice no matter if she does not approve entirely of the student put into the position. No requirement in the way of scholarship is demanded; just good, all-around fellows the students

admire. And in the ten years, not a set of officers has failed. The students know who is who, and no year is going to see its officers disgrace the Bowen Bird Boosters. It is an honor to be elected to office, and every fellow is determined to do his best if given that honor by fellow students.

The merits of the many forms of student government are still under discussion. It is plainly a fact, however, that when students are told that a club is theirs and theirs alone, they want that club to be the students' in fact and not only in theory. The wise faculty adviser must always remember that she is an adviser and not a president of that club. The officers should be confident of the teacher's ability and support. They should regard her as a friend when in office and as a teacher in the class room, relations which are very different. When high school students want their student organizations to be managed by students, many teachers seem to misunderstand. Students do not want the faculty advisers to sit back and say, "All right, if you want to run your own organization we will have nothing to do with your affairs." Students simply mean that they want cooperation on both sides. The faculty adviser should look after affairs as to preparation and advice and the students should carry such affairs out in their own ways and methods. Teach principles, and let the students apply them.

If science teachers really wish to humanize and make science work more practical, what better means could be found than a science club? But it takes time; in the case of the Bowen Bird Boosters it has taken ten years to build up a set of policies and principles making cooperation secure. If the faculty advisers wish to manage the business, if they wish to appear on programs, and if they desire to be conspicuous for their work, they cannot make students believe it is a students' club. The adviser's praise must be the club's growth in strength and influence. If the adviser disregards personal prejudices and treats students as equals in the same club, and if the club is founded and run on principles of student democracy, success is bound to result.

Not a great deal of business is necessary in such an organization, but that which is, must be handled in a business-like way. Our secretary's book contains the record of every meeting and event for the entire ten years. The treasurer's book and the accounts for the same are audited twice a year by the president and the faculty adviser. These are open at any time for the inspection of the members. Develop some traditions to bind the successive years together. We have a standard pin; each year the club subscribes for the magazine "Bird Lore" for the next year; each year the club leaves a present for the laboratory. The ten years have built up a bird-bath fund of $75.00. This bath will be cast this summer and placed in our school yard.

HOW CAN WE HUMANIZE THE GENERAL SCIENCE COURSE?

SUPERINTENDENT M. P. MITCHELL, HAMPSHIRE TOWNSHIP HIGH SCHOOL

Upon first attacking this subject one might be tempted to say that such a course does not need to be humanized; that all science, especially General Science which perhaps at best scratches only the surfaces of the special sciences, is in itself a humanized subject. Without doubt those science teachers present feel in regard to this subject that personally the subject is all of that to them. We have, however, to look at our classes to find some who have not found this subject to mean the same to them as we may have hoped. To me, the question confronting the teachers of this course is not so much the one of "Making the General Science Course Humanized" as it is of "Keeping the Course Humanized". There is no other subject in the Curriculum of the High School which should appeal more to the human curiosity and inquisitiveness than the General Science course.

The problem of keeping the course humanized or vitalized seems to be two-fold in nature. The first task of the teacher is to use only those methods of teaching which will appeal to the adolescent child before him. An analysis of my own teaching together with a recent survey of several schools clearly indicate that the most interest on the part of pupils is aroused through the laboratory work. This, then, should play an important part in the teaching program. The laboratory work may be administered in a number of different ways. In my first class in General Science I believe that I performed fully ninety per cent of the experiments for the class, permitting them to look on. Such a procedure did not satisfy the class or prove to be good teaching. I have completely changed my methods since that first teaching. I prefer to have my class perform as many individual experiments as time and other conditions permit. Next to this I prefer to have the class working in groups sufficiently small, so that every member of the group has an active part in the performance of the experiment.

Certainly the results obtained are more accurate when I personally carry on the experiments, but such results mean less to the members of the class. I much prefer the use of simple home-made apparatus to the elaborate and often expensive apparatus used in the more advanced science courses.

Too much emphasis cannot be laid upon class excursions or field trips. In addition to stimulating interest and providing a change in the regular routine of class work, such trips take the student to the right place to study science, that is, where nature has provided it. The class room with its artificiality does not often furnish the most suitable environment for teaching. True, most of the time must be spent there, but every opportunity should be taken to conduct the class work elsewhere.

In the class room itself much may be done to vitalize this subject. A regular routine question and answer method three times a week in the recitation room has been responsible for the waning of interest and enthusiasm on the part of the pupils. A little variety in the program not only appeals to the rather restless adolescent boy or girl but also gives to the careful teacher the key to the interest of the members of the class. The work may be varied in a number of ways. Special reports are always well liked. These subjects may be definitely assigned or left for personal selection by members of the class. Lectures or talks by the instructor or other people of the community may be used occasionally to advantage.

I believe that I have found nothing that appeals more to the child taking the science course than a definite personal problem for him to work out. The possibilities of such problems are unlimited in almost any community. Some may be wholly individual problems and others general or community problems: e. g.—

1. How much oxygen should be supplied to the class room per hour?

2. How much fertilizer will be needed to take the place of 1,000 bushels of corn sold *off* a farm?

3. What would be a good economical diet for a boy or girl of your age?

A few magazines are practically indispensable to the General Science course. I doubt if I would consider teaching another General Science class without the magazines listed below.

1. Popular Science Monthly.
2. Nature Magazine.
3. Hygiea.

In addition to these publications there are numerous exhibits prepared by various commercial companies, also pamphlets, circulars and bulletins. Perhaps the best supplementary material is to be found when conditions permit the use of a motion picture projector. Visual education has come to stay and when it is impossible to take the class to the subject under study, a very satisfactory substitute may be made by bringing films and slides to the class. The large number of companies producing educational films makes it a relatively easy matter to secure suitable films at small expense.

A feature of the work that I have found to be worth while during the present year is a Science Scrap Book. For this the children are asked to cut clippings, pictures, various kinds of specimens, etc., classify same and put in a book which they may keep. This encourages them to read, to observe carefully and in general ties up the science course with their daily life.

A Science Club presents many possibilities for humanizing the work in General Science. I regret to report that I have never seen my way clear to organize such a club as the time seemed well taken up with supervision, athletics, etc. The arguments however are all in favor of such a club providing the proper supervision and help can be given.

If this course is to be successfully humanized, the second task of the teacher is to eliminate undesirable elements. In addition to the elimination of the formal question and answer type of recitation, two other changes may be profitably made. Too often the beginning science course is made a one text book course. While there are several very good text books on this subject, and permit me to say that I personally consider our friend, Mr. Hessler's book to be the best on the market, yet the

science work will mean more to the class when several reference books are regularly used. It is not enough for a child to see a statement in one text book and accept the same for gospel truth without getting the opinions of several authorities upon the same topic. The more reference material used the more the course will mean to the class.

Without question the one feature of the science work most disliked by all the class is the note book work in connection with the laboratory experiments. Why should we as teachers demand so much from these beginning science students? Is it a natural condition to report in written form every important change or incident noted in Nature? Why then subject the child to the mental torture of this routine work? In several cases I find that the note book work must be done outside the regular laboratory. Heavy note book work soon becomes a drag upon the students with the result that all of the science work becomes distasteful, and enrollment in other science courses discouraged because of this one disagreeable factor. Of course some note book work should be given, but ample time should be provided in the laboratory period for such work. Only the most important experiments should be written up. There seems to be no good reason why the note book work could not be incorporated as a part of the English work. Apparently Freshmen in High School should be able to apply as much of their instruction in paragraphing, punctuation, vocabulary, etc., in the laboratory note book as in short stories, which usually accompanies the work in English.

What, then, are to be the aims of the General Science course? It might be inferred that the student is to be amused, his curiosity aroused and then be left to wonder why he has taken this particular course. One of my early science instructors made the statement that science seeks to know the "Hows" and "Whys" of nature. I believe this is not sufficient in itself. There are two other very important factors to be considered in successful teaching of science. They are, first "Where" and second, "How does this affect my life?" This last

phase is perhaps the most important, and should not only serve to arouse permanent interest in the various fields of science, but should also encourage individual thinking on the part of every boy and girl enrolled in this subject.

HOW CAN WE HUMANIZE HIGH SCHOOL SCIENCE?

CLARENCE BONNELL, HARRISBURG TOWNSHIP HIGH SCHOOL
BIOLOGY

Biology in many of our high schools has more or less the reputation of being one of the useless subjects. The popular characterization of the biology instructor with his eye-glasses, miscroscope, and butterfly net is often the counterpart of what parents and practical people in general think of a biologist. He is often considered a heretic religiously, especially in these days of fundamentalism and Bryanism. The writer has been the subject of prayers and warnings from the pulpit of a devout Southern Baptist pastor in a nearby village, from which some of his pupils have come; and a good Methodist brother in the home city has warned his Sunday school class against ever taking this damnable course in high school.

But for the fact that biology has gotten a "toe hold" in our high school course during twenty years of tactful handling of delicate questions, it would possibly be omitted now. I am glad to say that the classes are crowded and some have to be turned away each year. We think this is because the subject matter is made to connect so closely with the very life activities of those who take it, that they pass the word along to others the next year, for the course is an optional one.

Except for those who have actually had the course, or learn of it from their friends, it is considered a fad,—an impractical thing with no useful qualities such as are always associated with commercial courses, the manual and domestic arts, mathematics, physics, chemistry, or even dead languages, literature, or history. This mental attitude has resulted in turning biological subjects toward so called practical ends, such as agriculture and domestic science, so that true biology courses which give an organized account of the life processes of plants and animals have been quietly and gradually dropped from many high schools.

Such an attitude of opposition and indifference results largely from the sort of biology teaching had in the

past. Too many high school biology instructors are too much skilled in mysterious terminology and too little versed in the common every-day facts of life that are daily crowding about them and their students. Those whose tendencies have been toward the every-day manifestations of the life within and about them have been drawn to the more popular economic applications of biological knowledge and so are teachers of agriculture or domestic science. Thus it has become that the cartoonist's sketch of the bald headed, impractical anatomist peering through his microscope at the mangled remains of an unfortunate insect is not altogether without foundation in fact. Some of us are trying our dead level best to live down the imputation, but witness the yearly crop of high school annuals, or "take offs" in the class day exercises!

A few years ago, while at a meeting of the Illinois Academy of Science, I slipped away to a botany class in the high school in the same city. They were having laboratory work under a well trained lady from one of the largest universities. The subject was mush-rooms, and the material was in cans. It had been bought in Chicago. The instructions were in a manual. No conversation was permitted between pupils. I called the attention of the teacher to the fact that a fine collection of life size wax models of Illinois mushrooms was on display at the Academy meeting a few blocks away and that the students would be welcome either during school hours or after. None came. Was this a *human* way to act? Were these boys and girls permitted to react naturally toward mushrooms?

Biology may become the "livest" subject in school. This is possible if every recitation and every laboratory exercise is promptly and naturally connected up with the every day experiences of the child. I may mention but a few of these means of connecting formal instruction with the every day environment.

We collect material continually. Some organized collecting is done at certain appropriate seasons of the year. But every day is also a collecting day, and seldom a day passes that some specimen of plant or animal is not

brought in. It is understood that more credit is given those who thus interest themselves. Whatever the subject in hand, time is always taken to discuss the new specimen in class. If it is a snake, the question of its possibly being a poisonous one may arise. A dozen other points may be suggested. If it is a snake egg or frog's eggs, the method of propagation or the whole life history may be gone into. It takes skill acquired by experience to prevent such every day discussions from crowding out regular assignments. Nothing is so common or so strange that it will not excite interest. Last week, the music instructor found a mouse that had dropped into her empty metal waste basket and had later given birth to a family of four. These were promptly delivered to the biology room. Two days after, a litter of young rats was brought from home by one of the girls. Then it was that we discovered that eight out of about one hundred twenty students in four classes had not known till that day that rats are not grown up mice. Daily connection of farm, garden, household activities, and the student's own bodily activities with formal instruction continually brings up unexpected and startling ignorance of common live things about us. So, students and teachers do not grow stale over the subject.

A frank desire to know and to correct misunderstood situations is engendered. We find that we are taking a delight in ferreting out unfounded beliefs. It is surprising how many of them come to light. There is much of the superstition and mis-information which has been handed down from our forefathers and which still clings to us. We cover up superstition with scientific facts.

The making of a scrap book of biological clippings from current periodicals is one of our greatest aids in making everyone feel that biology is a living subject made up of things that are happening right now. Only five such clippings are required each month. The child is required to quote from his text or from a specified reference list of texts, something relating to the clipping. This is recorded in the scrap book, together with an original comment by the student. And here comes the rub. It is so hard to be original.

One illustration must serve to show further what I mean by devices to humanize this subject. About January 1st, a rabid dog bit a child in each of two families in our community, and a man and his wife and a child in another family. The first two families took their children to Chicago for the Pasteur treatment. The third family went some distance to a mad-stone which has local fame and is said to have been taken from the heart of a white deer. This stone is said to have been handed down to its present owner for several generations.

The local paper gave all these particulars and the article began to appear in our scrap books. Although we had not reached the topic "rabies" in our course, a full discussion was had in class. Soon after, the career of Pasteur was brought in as a laboratory day lecture. It was made clear that the family that had gone to the mad-stone was running a great risk. Last week the woman developed hydrophobia and died a horrible death. After the details came out in the paper, the matter came up in class and was further gone over. These young people have had one lesson at least that has gone home. This is humanizing biology.

HOW CAN WE HUMANIZE PHYSICS?

W. H. P. Huber, Elgin High School, Elgin

This paper has been prepared at the request of the Chairman of this section. The subject assumes that Physics as taught today is a dry, formal, and systematized subject which does not lend itself to the life needs and interest of the student. The charge may be partly true. If so it should merit the attention of every teacher interested in the welfare of the human race, so that it may be returned to its rightful sphere of influence and usefulness.

Probably the most important factor in humanizing Physics will be found in the teacher. First, he must have a good knowledge of the content of the subject and its relative value. More important still, he must be able to impart it to the student in such a simple way that it will be easy to understand. He must also be filled with enthusiasm for the work so that everyone in the class will be inspired to put forth his best effort. The view point and limitations of every individual in the class must be known.

Let us turn for a moment to the modern business men and industrial leaders; they no longer do things the way they did a decade ago. Old buildings are torn down. New and elaborate structures are erected. Old machinery is discarded; new and improved is installed. The latest and most efficient methods are sought and used. In teaching Physics the prudence of the business man and industrial leader should be followed. Traditional and devitalizing material should be eliminated. Formal methods may be changed. Highly specialized material frequently occurs in many of our text books. In most cases it will be better to omit the greater part. It is better adapted to students of an engineering school than to the average high school boy and girl. If used to any great extent it will confuse the mind and develop a lack of interest causing the course to become unpopular in the school.

Another important need today in nearly all secondary science is to secure a text-book with real scientific knowledge and stimulating material which functions in every

day life. The language must be simple and easy to comprehend. How often we hear the expression, "I do not understand a single thing in that paragraph," yet when the paragraph is explained the idea is simple and clear.

When subjects are studied in which formulas occur, concrete examples must be used and the real relation discovered before the algebraic statement is made. All laws should be developed by the same process. When the chapter on any subject is finished, summaries should be made, as they help the student to focus the mind on the points of importance. In new subject or advance assignments, all new words of importance should be pointed out or written on the board. If the student is required to complete a regular dictionary of these words and their definitions, he will more likely fix their meaning in his memory.

Special reports and themes furnish an excellent opportunity to introduce new and interesting material not found in the regular text. As a rule these should be brief and definite. Longer papers will nearly always be more profitable to the student if the teacher gives an outline and names references for wider reading. The reason for giving the outline is the elimination of irrelevant matter that might otherwise be used. The note book may also be used with profit to keep articles of special interest on the things studied in connection with those used in the text. The writer required each member of the class to make a collection of 25 different things involving the use of electricity. Comments were made on each thing and the electrical principle stated.

Field trips bring the classes into direct contact with the applied principles studied in the class or those to be studied. In nearly every case these prove to be more valuable than the more formal exercise of the laboratory. During the present semester the writer has taken his classes on three different field trips to study various phases of electricity.

In trying to get away from the more formal methods, one laboratory exercise in each class was devoted to the practical study of labor and time saving lamp socket devices. The Superintendent and three employees of the

Electric Light Company were present to conduct the exercise. The production and transmission of the current over high voltage wires was first considered by the Superintendent. After stating the reason for high voltage transmission it was explained how it was again stepped down and distributed to the various places for consumption. The limits of the lamp socket and use of fuses were next considered. Several different appliances were used and explained. The merits of each were considered. The amount of current consumed was determined by use of the voltmeter and ammeter. The cost per hour for each devise was found. The electrical driven brush and the straight type vacuum cleaner were compared. The advantages and disadvantages of each were pointed out to the class. The same was done with the vacuum and rotary washing machine.

One laboratory exercise has also been devoted to the study of ways in which alternating current can be changed to direct current. This exercise was taken up because a large number of storage batteries are used on radio outfits. Eight different types of rectifiers were secured and examined. The motor generator was studied and it was pointed out that it could be made by using an ordinary motor and an old generator from some discarded automobile. One boy later reported a good outfit with no cost except the time in a machine shop required to make a pully for the generator. Others made transformers and bought a tungar bulb at a considerable saving. Some made the more simple and less costly nodon valve rectifier. We devoted about a week to the subject of radio. Seven boys built neutrodyne sets and several built simpler sets.

Color and light in home decorating offers another interesting project for both the boys and girls. It is just as important as to study pitch quality and harmony in sound. How many of us know how to use complimentary colors? Where to use intensity of color and how much? How sunlight and artificial light cause the color to change, and why? What is meant by warm and cool colors and where to use them? How color and the size

of a room are related? What color and shade of drapes to use on a window, and why?

Similar projects which will appeal to the student can be found on almost every subject studied in Physics.

HOW CAN WE HUMANIZE HIGH SCHOOL CHEMISTRY?

ALBAN FIEDLER, EAST HIGH SCHOOL, AURORA

Professor Louis Sherman Davis says, "Interest in a science is proportional to the immediate bearing which its subject matter has upon the life of the student. Hence the matter and process with which chemistry deals should touch the life of the student as closely as possible." It would seem necessary, then, that the subject be kept in close contact with everyday life and that the work be made as practical as possible. With the great number of practical applications today, the danger is apt to be too great a digression into highly attractive subject matter which will interfere with the systematic teaching of the principles involved. The object of this paper is to summarize briefly a few devices which have been used successfully by the writer to teach the principle and fact with reference to their application.

Smith[1] says, "When a generalization has been stated it will find immediate application." He gives us several examples of application. The law of conservation of matter is illustrated by the raising of the same crop on the same piece of land year after year. In the absence of the law of definite proportion we could not regulate the heating of our houses because the rate of combustion would not depend upon the supply of oxygen. Similar illustrations of almost all the generalizations of chemistry may be found.

Visits to factories and industrial plants often furnish an opportunity to point out to the pupil an application of a principle or fact noted in the class room. By means of these visits he should be made to realize that chemical knowledge is practical and to see that there is a definite relation between the test tubes of the laboratory and the vats of the factory. To be really profitable, such excursions must be made with a definite plan covering the things to be seen. Many questions will be suggested by what has been seen. So the first recitation after an excursion should be devoted to answering these and to assigning further study based on these observations. The

[1] Smith & Hall, pp. 129, 130.

excursion may take the place of a laboratory exercise.

Obviously, it will be impossible to bring a great many industrial processes before the pupils except by means of moving pictures. Miller[2] says, "The film has far-reaching potential usefulness in the study of chemical processes and manufacturing." Plant processes can be thrown on the screen anywhere. The class discussions of the pictures should bring out the important points. To quote Miller again regarding the use of films, "The point to be safeguarded is to see to it that it is used as a means in clarifying or economizing the pupils' productive thinking. If the pupil is transformed from the spectator to the participant the evils of the film disappear."

Collections of chemicals and specimens are very helpful for illustrating the applications of chemistry to industry. A pupil's interest in the process involved in the manufacture of common glass, for example, is intensified considerably when he sees specimens of the raw materials, the mixture and the finished articles. Smith[3] says, in regard to connecting things that are natively interesting with other things which are not so, "It is one of the best means of lending interest to facts that might otherwise seem dry." Charts such as the Coal Tar Products Tree can be used to good advantage. Specimens and charts may often be obtained from the manufacturer for the asking.

Aside from the reference works of a more or less technical nature, books like those of Slossons[4] and Duncan[5] can be put to good use. They present the romantic aspects of chemistry and are highly interesting to the average student. If the principles taught in chemistry seem dry, why not develop the pupil's interest by placing books of this type in his hands? In a great many cases the generalizations underlying the descriptive matter in books of this type can be brought home more easily and made to seem less dry to the student. In a number of instances I have used to advantage advertising literature

[2] Directing Study, p. 53.
[3] Smith & Hall, p. 141.
[4] Slosson's "Creative Chemistry."
[5] Duncan's "Chemistry of Commerce" and "Some Chemical Problems of Today."

describing the process of manufacturing, properties, and uses of various commercial articles. Our bulletin board is usually pretty well loaded with newspaper and magazine clippings brought in by the pupils. "The Science News-Letter" is a reliable source of material covering the latest development in chemistry as well as in other sciences. Material of the sort mentioned above may be assigned as topics and the presentation of these topics may be followed by a discussion of the principles involved.

Experiments should furnish data and information to be used in recitation. The best results will be obtained when the pupil is seeking an answer because he is interested in doing so. As an illustration take the "Determination of the concentration of a solution by titration". When done according to the directions given in most laboratory manuals the results are discouraging and the pupil loses interest. Let the object of the experiment be stated as "What is the most economical brand of household ammonia to purchase?" and have the pupils bring samples from home. From the standpoint of the pupil there is an entirely different problem—one in which he is vitally interested. Whenever time permits, the pupils should be encouraged to bring in materials to test in various ways, and the results should be reported to the class. In connection with tests for food adulterations, etc., the results cover a wider range if each pupil brings samples to be tested from home.

"The practice of topping out a course in chemistry with a large unit of work, either on the individual or the co-operation basis, is suggested."[6] Some weeks before the close of a year's course, the pupils may be given a choice of problems such as wood-products, soils, photography, etc., and the laboratory periods given over to experimental work on these problems. The pupils may be required to make a report each week to the teacher showing the progress made. A pupil usually finds it necessary to understand the generalizations of chemistry and to apply these in the development of his project. The results may be exhibited to the public at the close of the

[6] Miller "Directed Study" pp. 164, 165.

year. There is an incentive to work because the pupil has chosen a problem which appeals to him. The earnestness and enthusiasm shown is gratifying.

Much might be written on the use of any of the above devices. There is no claim for anything original. But if this rambling paper has brought back to the mind of anyone here something which may be of use, it will have accomplished its purpose.

MAKING SCIENCE TEACHING MORE EFFECTIVE IN RELATION TO LIFE

H. A. Hollister, University of Illinois

The chief life contacts of science may be classed under *health, morals* and *industry*. The question before us therefore is: What constitutes effective teaching in relation to these three great divisions of life interests?

Speaking of super power, or what is more commonly called giant power, Gov. Pinchot of Pennsylvania says: "Giant power is a term coined to suggest the realization of far reaching social objectives through a vaulting engineering technique. It means giving to every producer of current an opportunity to add to the common stock and to every user an opportunity to draw therefrom, but it also means the education of the public, to the point where it can intelligently and fully cooperate with public and private enterprise in these objectives."

R. F. Schardt of the Commonwealth Edison, quoting Pinchot, goes on to say: "This is constructive recognition of the biological factor in civilization, a restatement that engineering objectives are affected by the human stock. The technical progress of civilization cannot be indefinitely continued, nor even the present status maintained, unless some attention is paid to improving the personnel which man the machine."

This brings to the fore the problem of health as really underlying the whole fabric of human existence, especially as our social order advances to higher levels of attainment in all those things which characterize modern civilization as ever advancing.

The first and most fundamental call, therefore, which human life makes on science is the instilling into the minds of youth the value of life at its best and the means of preserving it and projecting it on to coming generations with increasing rather than diminishing virility, and with adaptability to every changing social and physcal condition. This means the training in knowledge and practice of the laws of health of body and mind; of how to conserve, rather than to waste, one's physical resources and mental inheritance; of how to care for the propa-

gation of the race so as to eliminate inherent weakness, both physical and mental; of how, in other words, to produce and preserve a super man, in the true sense, to deal with super power for human weal.

The moral element enters here, for morals and health are closely related at many points. But in all our teaching let us emphasize the *doing* of the things that need to be done rather than the *don'ts* with their vicious suggestiveness and their appeal to the daring of youth. The common, everyday conditions of living seem here to demand a new stating in terms of what biology has taught us. This applies to both the moral and the health aspects of our problem.

It seems needless to enumerate here all the elements which center around this particular phase of science teaching. They are well known to us all. What we should strive for is to give to our pupils a consciousness of real objectives to be attained if they are to live their lives to the greatest advantage for themselves and for posterity. Where we have been failing in this particular is in not making any clear and definite use of what science has already taught us. To quote from the same source as above: "Hardly a trace of this scientific knowledge has been applied, positively or negatively, to the betterment of the human stock. How long a scientific civilization, making ever increasing demands upon the ability of the people, can be maintained under such conditions is becoming a pressing issue."

That is another way of saying that it is the mission of the school, as far as the teaching of science is concerned, not only to instruct youth in the principles of biology and physics, but to introduce them, as far as possible, to the practical applications of these principles in the home, in the community, in business and in industry. And the more nearly such scientific attitudes become habitual the more successful will be our teaching. Sanderson of Oundel had the right idea when he set out to teach his boys science by attacking the problems of daily life in his school community. As a result, and also as an acid test of the sanity of his method, when the world war came on, his boys thus trained were able at once to as-

sume tasks of grave responsibility in applying science to the many hurried readjustments that the modern conditions of warfare into which the British nation was plunged demanded.

The principle is no less true under peace conditions. How urgent are the needs of many readjustments of the rank and file of our citizenry in these days of radical innovations in all the fundamental aspects of living! And how true it is that in our haste for material development we have forgotten the corresponding need of applying the latest word in science to the conservation and improvement of the human biological factor. We see this in the risk to lives that comes along with the invention of complex machines. This is notably true of the automobile now in common use, and yet a large percentage of the users know little of the mechanism they undertake to direct in the midst of ever increasing traffic. For the driver who takes the trouble to know and master his car, and to consider the risks, the danger is always from the "other fellow." Thus both in education and in the moral sense of responsibility for others our biological advancement is far behind the demands of this age of the application of physics and chemistry in doing the world's work.

We need a different literature of science, one that may be broadcasted with the hope that all who listen in may comprehend. We need more of such material as Slosson's "Creative Chemistry," of Hunter's "Civic Biology," in order that the masses, through our schools, may learn the language of science as applied to living. We need more teachers of science like Miss Smallwood and Miss Loomis of Chicago, Miss Huffman of Woodstock, and Clarence Bonnell of Harrisburg,—teachers who make science a living thing that vibrates throughout all that is important and vital in our social and civic life.

As has been suggested, we have been stressing too much the material benefits of science as applied to commerce and industry to the serious neglect of its application to the biological wellbeing of our people. It is not enough to assign text-book lessons and perform a few experiments in the laboratory in order to "pass" and earn

a "credit." We need to teach the language of science so that our youth may be able to read intelligently and also with interest the results of research as they apply to the great fundamental interests of life. The vast expenditures of the national government and of institutions in conducting experiments and research are still failing of accomplishment with the majority of those who should profit by their published results because they are unable to read the literature of science with understanding and appreciation. As one illustration, note the premium that men still put upon the services of the chef who can most skillfully concoct the dishes that, because of their delectable qualities that tickle men's palates, lead to a stuffing and gormandizing that end in premature death or incompetency. On the other hand, men listen, how grudgingly, to the trained dietician who seeks to enlighten them on the relation of food elements to normal bodily functioning and consequent health.

We hear much these days about conflicts between religion and science. This because we, as science teachers, have failed to compare the eternal verities of science with the fundamental teachings of religion. Yet what more important relationship to life than this does science hold for us as individuals and as a Christian nation?

I can do no better than to quote here from an article by Professor T. E. Savage in the March number of "The Open Court." Professor Savage is a Geologist of no mean ability and his word may well command our attention. He says:

"If God's presence permeates nature in such an intimate way, we should expect to find nature's laws teaching the same moral lessons as the Bible, and working along lines parallel with it in bringing about righteousness in the earth. In a very large way this is true. The Bible says, 'Prove all things, hold fast to that which is good.' Science has accepted this rule as one of its fundamental principles. The Bible says, 'The Wages of sin is death.' Science repeats the same warning and shows us how nature works to bring about this result. When a man indulges in evil practices and persistently transgresses the laws of health, his physical vigor and power

of resistance are lessened thereby, and he falls an early victim to disease. Nature detects even those who appear to be sound, but are rotten at the core. The Bible says, 'The iniquities of the fathers are visited upon the children to the third and fourth generations.' Science shows clearly the truth of this statement. Where parents are dissolute and victims of sinful habits, the children also possess weakened constitutions as well as sinful tendencies, either as a result of inheritance, or of early environment and neglect. Where for only a few generations parents are persistently vicious the stock grows weakened, idiotic, and eventually becomes extinct. Persistent sinfulness is stamped out in a few years by natural selection acting through heredity. In the language of science the sinner is out of harmony with his environment, and if he and his posterity will not or can not change, natural selection will as surely cut off his race as in the case of any other animal not in adjustment with its environment. This is 'the power not of ourselves that makes for righteousness.' Happily, in a similar way the higher qualities of character developed by the parents are also impressed upon the children by early education and example. The Bible says, 'The righteous shall inherit the earth,' and science assures us that righteousness or right living makes for health and length of life."

Surely in this grossly materialistic age we may well stress such ideals in our teaching of the fundamentals of science to those who are the hope of the future.

CONSTITUTION AND BY-LAWS

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Illinois State Academy of Science

CONSTITUTION.

ARTICLE I. NAME.

This Society shall be known as THE ILLINOIS STATE ACADEMY OF SCIENCE.

ARTICLE II. OBJECTS.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members*.

National Members shall be those who are members also of the American Association for the Advancement of Science. Each national member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of five dollars.

Local Members shall be those who are members of the local Academy only. Each local member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members*, *Active Members*, or *Non-resident Members*.

Life Members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars. Life members, if national members, shall pay an annual assessment of four dollars.

Active Members shall be national or local members who reside in the State of Illinois, and who have not paid as much as $20.00 in fees to the Academy.

Non-resident Members shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

Charter Members are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

ARTICLE IV. OFFICERS.

The officers of the Academy shall consist of a President, a 1st Vice-President, a Librarian, a Secretary, and a Treasurer. The Chief of the Division of State Museum of the Department of Registration and Education of the state government shall be the Librarian of the Academy. The other above officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

A 2nd Vice-President, who may be a resident of the town in which the next annual meeting is to be held, may be appointed by the council each year when the next meeting place shall have been decided upon.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, Vice-President, Secretary, Treasurer, Librarian, the retiring president and his immediate predecessor. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

At the Annual Meetings the presiding officer of all the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication, a Committee on Membership and a Committee on Affiliation and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary and a third member chosen annually by the Academy.

The Committees on Membership and Affiliation shall each consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council, and shall be called upon written request of twenty members.

Article VIII. Publications.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and may be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meetings of the Academy shall be held without thirty days previous notice by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting.

IX. The Secretary and the Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS

List of Members

Note—The names of charter members are starred; names in black-faced type indicate membership in the American Association for the Advancement of Science.

LIFE MEMBERS.

***Andrews, C. W.,** LL. D., The John Crerar Library, Chicago, Ill. (Sci. Bibl.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield, Ill. (Bacteriology.)
Barber, F. D., M. S., Illinois State Normal University, Normal, Ill. (Physics.)
Barnes, R. M., LL. B., Lacon, Ill. (Zoology.)
Barnes, William, M. D., 320 Millikin Bldg., Decatur, Ill. (Lepidoptera.)
***Bartow, Edward,** Ph. D., University of Iowa, Iowa City, Iowa.
Chamberlain, C. J., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
Chamberlain, T. C., LL. D., University of Chicago, Chicago, Ill. (Geology.)
Cowles, H. C., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
***Crew, Henry,** Ph. D., Northwestern University, Evanston, Ill. (Physics.)
***Crook, A. R.,** Ph. D., Chief State Museum, Springfield, Ill. (Geology.)
Deal, Don W., M. D., Leland Office Building, Springfield, Ill. (Medicine.)
Farrington, O. C., Ph. D., Field Museum, Chicago, Ill. (Minerology.)
Ferriss, J. H., Joliet, Ill. (Conchology.)
***Fischer, C. E. M.,** M. D., Marshall Field Annex Bldg., 25 E. Washington St., Chicago, Ill. (Medicine.)
***Forbes, S. A.,** LL. D., Chief, Natural History Survey, Urbana, Ill. (Zoology.)
Fuller, Geo. D., Ph. D., University of Chicago, Chicago, Ill. (Botany.)
*Gates, Frank C., Ph. D., State Agricultural College, Manhattan, Kansas. (Botany.)
Hagler, E. E., M. D., Capitol Ave. and Fourth St., Springfield, Ill. (Oculist.)
Hankinson, Thos. L., B. S., State Normal College, Ypsilanti, Mich. (Zoology.)
***Hessler, J. C.,** Ph. D., Knox College, Galesburg, Ill. (Chemistry.)
Hinkley, A. A., Dubois, Ill. (Conchology.)
Hoskins, William, 111 W. Monroe St., Chicago, Ill. (Chemistry.)
Hunt, Robert T., Decatur, Ill. (Soils.)
Jordan, Edwin O., Ph. D., University of Chicago, Chicago, Ill. (Bacteriology.)
Kunz, Jakob, Ph. D., 1205 S. Orchard St., Urbana, Ill. (Physics.)
Latham, Vida A., M. D., D. D. S., 1644 Morse Ave., Chicago, Ill. (Microscopy.)
Lillie, F. R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Marshall, Ruth, Ph. D., Rockford College, Rockford, Ill. (Zoology.)
Miller, G. A., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.)
Moffatt, Mrs. Elizabeth M., Wheaton, Ill.
Moffatt, Will S., M. D., 105 S. LaSalle St., Chicago, Ill. (Botany.)
Mohr, Louis, 349 W. Illinois St., Chicago, Ill.
***Noyes, William A.,** Ph. D., LL. D., University of Illinois, Urbana, Ill. (Chemistry.)
***Oglevee, C. S.,** Sc. D., Lincoln College, Lincoln, Ill. (Biology.)
Payne, Edward W., First State Trust & Savings Bank, Springfield, Ill. (Archeology.)
*Pepoon, H. S., M. D., Lake View High School, Chicago, Ill. (Zoology, Botany.)
Rentchler, Edna K., B. A., Peabody Normal College, Nashville, Tenn. (Biology.)
***Smith, Frank,** M. A., University of Illinois, Urbana, Ill. (Zoology.)
***Smith, Isabel Seymour,** M. S., Illinois College, Jacksonville, Ill. (Botany.)
Smith, L. H., Ph. D., University of Illinois, Urbana, Ill. (Plant Breeding.)
Stevenson, A. L., B. S., Field School, 7019 N. Ashland Ave., Chicago, Ill.
Stillhamer, A. G., 705 N. East St., Bloomington, Ill. (Physics.)
Sykes, Mabel, B. S., South Chicago High School, Chicago, Ill. (Geology.)
Trelease, William, LL. D., University of Illinois, Urbana, Ill. (Botany.)
Ward, Henry B., Ph. D., University of Illinois, Urbana, Ill. (Zoology.)
Washburn, E. W., Ph. D., National Research Council, Washington, D. C. (Chemistry.)
Weller, Annie L., Eastern Illinois State Teachers College, Charleston, Ill.
***Weller, Stuart,** Ph. D., University of Chicago, Chicago, Ill. (Paleontology.)
Zeleny, Charles, Ph. D., University of Illinois, Urbana, Ill. (Experimental Zoology.)

ANNUAL MEMBERS.

Abbott, Howard C., University of Illinois, Urbana, Ill.
Abrams, Duff A., C. E., Lewis Institute, Chicago, Ill. (Structural Materials.)
Adams, L. A., 605 W. Indiana Ave., Urbana, Ill.
Adler, Herman M., M. D., 721 S. Wood St., Chicago, Ill. (Medicine.)
Alexander, Alida, M. A., Illinois Woman's College, Jacksonville, Ill. (Botany.)
Alexander, C. P., Ph. D., Fernald Hall, Mass. Agri. College, Amherst, Mass. (Entomology.)
Alldredge, Samuel M., A. B., P. O. Box 682, Johnston City, Ill. (Chemistry.)
Allee, W. C., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Ames, E. S., Ph. D., University of Chicago, Chicago, Ill. (Psychology.)
Anderson, H. W., 811 Michigan Ave., Urbana, Ill. (Plant Pathology.)
Anderson, S. L., M. D., DeKalb, Ill. (Medicine.)
Andras, J. C., B. A., 540 S. Main St., Manchester, Ill. (Astronomy, Botany.)
Armstrong, Christie, A. B., Princeville, Ill. (Physiography.)
Ashman, George C., Ph. D., Bradley Institute, Peoria, Ill. (Chemistry.)
*__Atwell, Chas. B.,__ Ph. M., Northwestern University, Evanston, Ill. (Botany.)
Augur, Allison W., M. A., 11359 S. Irving Ave., Chicago, Ill. (Physics.)
Bacon, Chas. Sumner, Ph. D., M. D., 2156 Sedgwick St., Chicago, Ill.
Bailey, Wm. M., M. S., 701 S. Poplar St., Carbondale, Ill. (Botany.)
Baker, Frank C., University of Illinois, Urbana, Ill. (Zoology, Conchology.)
Balduf, W. V., Ph. D., University of Illinois, Urbana, Ill. (Entomology.)
Ball, John R., M. A., 820 Hamlin St., Evanston, Ill. (Geology.)
Bangs, Edward H., 212 W. Washington St., Chicago, Ill. (Agriculture, Electricity.)
Barnes, Cecil, LL. B., M. A., 1522 1st National Bank Bldg., Chicago, Ill. (Physical Geography.)
Barwell, John Wm., Madison and Sands Sts., Waukegan, Ill. (Anthropology.)
Bastin, E. S., Ph. D., University of Chicago, Chicago, Ill. (Geology.)
Bayley, W. S., Ph. D., University of Illinois, Urbana, Ill. (Geology.)
Beal, James Hartley, Sc. D., 801 W. Nevada St., Urbana, Ill. (Pharmaceutical.)
Behre, Chas. H., Jr., University of Cincinnati, Cincinnati, Ohio.
Bentley, Madison, Ph. D., University of Illinois, Urbana, Ill. (Psychology.)
Benton, Curtis, B. A., McComb, Ill. (Entomology.)
*__Betten, Cornelius,__ Ph. D., Cornell University, Ithaca, N. Y., (Biology.)
Bevan, Arthur, Ph. D., University of Illinois, Urbana, Ill. (Geology.)
Black, Arthur D., M. A., M. D., D. D. S., Northwestern University, Evanston, Ill. (Dentistry.)
Blake, Anna M., B. S., 203 N. School St., Normal, Ill. (Botany, Physiology.)
Blake, Mrs. Tiffany, 25 East Walton Place, Chicago, Ill.
Bleininger, A. V., B. S., Care of Homer Laughlin China Co., Newell, W. Va. Ceramics.)
Bohannan, F. C., B. S., Galesburg High School, Galesburg, Ill. (Geology, Geography.)
Bonnell, Clarence, Township High School, Harrisburg, Ill. (Biology.)
Boomer, S. E., M. A., 207 Harwood St., Carbondale, Ill. (Physics.)
Boot, G. W., M. D., 813 Sherman Ave., Evanston, Ill. (Medicine, Geology.)
Boys' Science Club, Galesburg High School, Galesburg, Ill.
Breed, Frederick S., Ph. D., 5476 University Ave., Chicago, Ill. (Education.)
Brennan, George A., 24 W. 110th pl., Chicago, Ill. (Principal Van Vlissingen School.
Bretz, J. Harlan, Ph. D., University of Chicago, Chicago, Ill. (Geology.)
Brink, Chester A., M. D., Apple River, Ill. (Medicine.)
Brophy, Truman W., D. D. S., M. D., 81 E. Madison St., Chicago, Ill. (Medicine.)
Brown, Agnes, 1205 West State St., Rockford, Ill.
Brown, George A., 304 E. Walnut St., Bloomington, Ill. (Education.)
Brown, Howard C., B. S., 409 Hamilton St., Geneva, Ill. (Botany.)
Brown, Walter J., M. D., 151 N. Vermillion St., Danville, Ill. (Medicine.)
Browne, George M., 902 S. Normal St., Carbondale, Ill. (Chemistry.)
Buckingham, B. R., Ph. D., Director of Bureau of Educational Research. Ohio State University, Columbus, Ohio. (Education.)
Burmeister, Wm. H., M. D., 536 Deming Place, Chicago, Ill. (Exp. Medicine.)
Buswell, A. M., Chief, State Water Survey, University of Illinois, Urbana, Ill.
Buzzard, Robt. G., M. S., State Normal University, Normal, Ill. (Geography, Geology.)

Cahn, Alvin R., M. S., University of Illinois. (Zoology.)
Caldwell, Delia, M. D., 590 W. Main St., Carbondale, Ill. (Medicine.)
Campbell, Ian, M. A., 11 Conant Hall, Cambridge, Mass. (Geology.)
Carlson, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physiology.)
Carlson, Fred, Ed. B., State Teachers College, DeKalb, Ill. (Geography.)
Carmen, Albert P., Ph. D., University of Illinois, Urbana, Ill. (Physics.)
*__Carpenter, Chas. K.__, D. D., 311 Park St., Elgin, Ill.
Causey, David, University of California, Berkley, Cal. (Biology.)
Challis, Frank E., 121 N. Wabash Ave., Chicago, Ill. (Analin Dyes.)
Chandler, S. C., B. S., R. R. 5, Carbondale, Ill. (Entomology.)
*__Child, C. M.__, Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Christie, J. R., B. S., M. S., East Falls Church, Virginia. (Biology.)
Clark, Albert Henry, B. S., 701 W. Wood St., Chicago, Ill. (Chemistry.)
Clark, H. Walton, M. A., Steinhardt's Aquarium, Golden Gate Park, San Francisco, Cal. (Biology.)
*__Clawson, A. B.__, B. A., Dept. of Agriculture, Washington, D. C. (Biology.)
Clement, John A., Ph. D., Northwestern University, Evanston, Ill. (Psychology, Education.)
Cletcher, J. O., M. D., 10 N. Main St., Tuscola, Ill. (Medicine.)
Clute, W. N., Editor "The American Botanist", Joliet, Ill. (Botany.)
Coffin, Fletcher B., Ph. D., Lake Forest, Ill. (Physical Chemistry.)
Coggeshall, Ruth, B. S., 3927 Hamlin Ave., Chicago, Ill. (Biology.)
Colby, Arthur Samuel, Ph. D., 413 University Hall, University of Illinois, Urbana, Ill. (Pomology, Pathology, Medicine.)
Colby, Chas. C., Ph. D., University of Chicago, Chicago, Ill. (Geography.)
Colyer, F. H., M. S., State Normal University, Carbondale, Ill. (Geography.)
Combs, Ralph Marion, 706 W. Main St., Decatur, Ill. (Biology.)
Compton, James S., Eureka College, Eureka, Ill.
Cone, Albert Benjamin, 5245 Magnolia Ave., Chicago, Ill. (Forestry, Microscopy.)
*__Coulter, John M.__, Ph. D., University of Chicago, Chicago, Ill. (Botany.)
*__Crandall, Chas. S.__, University of Illinois, Urbana, Ill. (Botany.)
Crathorne, A. R., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.)
Creager, Gail, Ed. B., Pinckneyville, Ill. (Biology.)
Crocker, William, Ph. D., Care of J. M. Arthur Thompson Institute. Yonkers, N. Y. (Botany.)
Crosier, W. M., M. D., Alexis, Ill. (Medicine.)
Cross, Chas. H., Science Teacher, Y. M. C. A., Freeport, Ill. (Biology, Chemistry.)
Crowe, A. B., M. A., Eastern State Teachers College, Charleston, Ill. (Physics.)
Cullison, Aline, 1735 E. 67th St., Chicago, Ill.
Culver, Harold E., Ph. M., State Geological Survey, Urbana, Ill. (Geology.)
Danville Science Club, High School, Danville, Ill. (General.)
Darling, Elton R., Ph. D., 1345 West Macon Ave., Decatur, Ill.
Dart, Carlton R., 706 Greenleaf Ave., Wilmette, Ill.
Davenport, Eugene, LL. D., Woodland, Mich. (Agriculture.)
Davies, D. C., Director Field Museum, Chicago, Ill.
*Davis, J. J., B. S., Purdue University, Lafayette, Ind. (Entomology.)
Deam, Hon. Chas. C., M. A., Bluffton, Ind. (Forestry, Flora.)
Dean, Ella R., B. Ed., 310 E. Elm St., Olney, Ill. (Chemistry.)
DeLee, Jos. B., M. D., M. A., 5028 Ellis Ave., Chicago, Ill.
Dempster, A. J., Ph. D., Ryerson Physical Lab., University of Chicago, Chicago, Ill. (Physics.)
DeTurk, Ernest E., Ph. D., 707 W. Green St., Urbana, Ill. (Agriculture.)
Dilts, Charles D., A. B., 3121 Fairfield Ave., Fort Wayne, Ind. (Chemistry.)
Doll, Theodore, M. A., Nova Springs, Floyd Co., Iowa. (Mathematics.)
Downie, Thomas R., 1216 N. Kellogg St., Galesburg, Ill. (Geology.)
Downing, Elliot R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Dufford, R. T., 104 Physics Bldg., University of Missouri, Columbia, Mo (Physics.)
Dunn, Charles F., 1912 S. 9th Ave., Maywood, Ill.
Dye, Marie, M. S., 1700 E. Michigan Ave., Lansing, Mich. (Chemistry.)
Earle, C. A., M. D., DesPlaines, Ill. (Botany.)
East, Clarence W., M. D., F. A. S. C., 326 W. Jackson St., Springfield, Ill. (Preventive Medicine.)
Ehrman, E. H., M. E., Homan Ave. and Fillmore St., Chicago, Ill.
Eifrig, C. W. G., 504 Monroe Ave., Oak Park, Ill. (Ornithology, Botany, Zoology.)
Ekblaw, George E., A. M., State Geological Survey Division, Urbana, Ill. (Geology.)
Ekblaw, W. E., Ph. D., 711 W. Nevada St., Urbana, Ill. (Geology.)
Eldredge, Arthur G., Physics Bldg., University of Illinois, Urbana, Ill. (Photography.)
Eller, W. H., S. B., State Teachers College, Macomb, Ill. (Physics.)

Elliott, A. T., B. S., P. O. Box 1221, East Chicago, Ind. (Science.)
Englewood High School General Science Club, 62nd St. and Stewart Ave., Chicago, Ill.
Englis, Duane T., Ph. D., 358 Chemistry Bldg., University of Illinois, Urbana, Ill. (Chemistry.)
Eureka Science Club, Eureka Twp. High School, Eureka, Ill.
*Ewing, Dr. H. E., Dept. of Insectology, Smithsonian Institute, Washington, D. C. (Biology.)
Farwell, Mrs. Francis C., 1520 Astor St., Chicago, Ill.
Featherly, H. I., Waterloo, Ill. (Biology, Agriculture.)
Feuer, Bertram, B. S., M. S., 2634 Argyle St., Chicago, Ill. (Chemistry, Bacteriology.)
Finley, C. W., M. A., The Lincoln School, Teachers College, Columbia University, New York. (Zoology.)
*Fisher, Fannie, Asst. Curator, State Museum, Springfield, Ill. (Gen. Interest.)
Flint, W. P., Asst. State Entomologist, 1006 South Orchard St., Urbana,
Foard, Castle W., M. S., 990 E. Brooks St., Galesburg, Ill. (Physics.)
Foberg, J. Albert, B. S., Camp Hill, Pa. (Mathematics.)
Folsom, Justus W., Sc. D., University of Illinois, Urbana, Ill. (Entomology.)
Franing, E. C., M. D., 404 Bank of Galesburg Bldg., Galesburg, Ill. (Medicine.)
Franing, Russell, A. B., Elgin Academy, Elgin, Ill. (Chemistry.)
Frank, O. D., 5825 Drexel Ave., Chicago, Ill. (Biology.)
Franklin Science Club, Community High School, Pleasant Hill, Ill.
French, G. E., M. A., Herrin Hospital, Herrin, Ill. (Botany, Entomology.)
Frison, Theodore H., Natural History Building, University of Illinois, Urbana, Ill. (Entomology, General Biology.)
Fuller, Margaret B., Ph. D., 14 University Hall, Northwestern University, Evanston, Ill. (Geology.)
Gantz, R. A., 411 N. Talley St., Muncie, Ind. (Botany.)
Gault, B. T., 564 N. Main St., Glen Ellyn, Ill. (Ornithology.)
Genauque, H. A., 531 Lombard St., Galesburg, Ill. (Chemistry.)
Gerard, R. W., B. S., 2811 Cottage Grove Ave., Chicago, Ill.
Gerhard, Wm. J., Field Museum, Chicago, Ill.
Gerould, T. F., M. D., 115½ N. Locust St., Centralia, Ill. (Medicine.)
Glattfeld, J. W. E., Ph. D., Kent Chemical Laboratory, University of Chicago, Chicago, Ill. (Chemistry.)
Goode, J. Paul, Ph. D., 6227 Kimbark Ave., Chicago, Ill. (Geography.)
Gore, G. W., M. D., 231 N. McCleamsboro St., Benton, Ill. (Internal Medicine.)
Gorrell, T. J. H., M. D., Chicago Heights, Ill. (Medicine.)
Gould, William C., A. B., M. A., State Teachers College, DeKalb, Ill. (Geography.)
Gradle, Harry S., M. D., 22 E. Washington St., Chicago, Ill. (Ophthalmology.)
Graham, R., 105 Animal Pathology Bldg., University of Illinois, Urbana, Ill.
***Grant, U. S.,** Ph. D., Northwestern University, Evanston, Ill. (Geology.)
Green, Bessie, M. A., University of Tennessee, Knoxville, Tenn. (Zoology.)
Greenman, J. M., Ph. D., Missouri Botanical Garden, St. Louis, Mo. (Botany.)
Griffith, C. E., Ph. D., 209 University Hall, University of Illinois, Urbana, Ill. (Psychology.)
Gronemann, Carl F., 310 N. Liberty St., Elgin, Ill. (Artist, Naturalist.)
Guberlet, John E., Ph. D., Okla. A. & M. College, Stillwater, Okla. (Zoology.)
Gurley, William F. E., 6151 University Ave., Chicago, Ill. (Paleontology.)
Haas, William H., M. A., Northwestern University, Evanston, Ill. (Geography.)
Hadley, Geraldine, B. A., Bradley Polytechnic Inst., Peoria, Ill. (Domestic Science.)
*Hale, John A., M. D., Bush, Ill. (Medicine.)
Hall, Earl H., 999 Spring Garden St., Greensboro, N. C.
Hance, James H., Ph. D., University of Illinois, Urbana, Ill. (Geology.)
Hanna, Joseph V., A. M., Joliet High School and Junior College, Joliet, Ill. (Psychology.)
Hansen, Paul, 39 W. Adams St., Chicago, Ill. (Sanitation.)
Hanson, Alyda C., B. S., Chicago Normal College, 68th St. and Stewart Ave., Chicago, Ill. (Geography, Geology.)
Hardin, Sarah M., Ph. B., 402 W. Walnut St., Carbondale, Ill. (Biology.)
Harding, H. A., Ph. D., P. O. Box 834, Detroit, Mich. (Bacteriology.)
Harkins, William D., Ph. D., 5437 Ellis Ave., Chicago, Ill. (Chemistry.)
Hartsough, Ralph C., B. S., A. M., Illinois Wesleyan University, Bloomington, Ill.
Hauberg, John H., B. S., LL. B., 23d St. Hill and 13th Ave., Rock Island, Ill. (Botany.)

Hauberg, Mrs. John H., 23d St. Hill and 13th Ave., Rock Island, Ill.
Haupt, Arthur W., St. Lawrence University, Canton, N. Y. (Botany.)
Hawthorne, W. C., B. A., B. S., Crane Junior College, Chicago, Ill. (Physics.)
Heflin, H. N., M. D., Kewanee, Ill. (Medicine.)
Hemenway, Henry B., M. D., 620 Amos Ave., Springfield, Ill. (Public Health.)
Henning Community High School Science Club, Henning, Ill.
Herrick, C. Judson, Ph. D., Dept. of Anatomy, University of Chicago, Chicago, Ill. (Anatomy, Neurology.)
Higgins, D. F., B. S., M. S., Claremont, Ill. (Geology.)
Higgins, George M., Ph. D., Inst. Experimental Medicine, Rochester, Minn. (Zoology.)
Hildebrand, L. E., M. A., New Trier Township High School, Kenilworth, Ill. (Zoology.)
•**Hill, W. K.,** Carthage College, Carthage, Ill. (Biology.)
Hinchliff, Grace, 715 N. Broad St., Galesburg, Ill.
Hines, Murray A., Ph. D., 1610 Oak Ave., Evanston, Ill. (Chemistry.)
Hoffman, Frank F., M. D., 3117 Logan Blvd., Chicago, Ill. (Phys-Surg.)
Holgate, T. F., LL. D., 617 Library St., Evanston, Ill. (Mathematics.)
Holmes, Manfred J., B. L., 703 Broadway, Normal, Ill. (Social and Education.)
Honey, Edwin E., B. S., Cornell University, Ithaca, N. Y. (Plant Pathology, Botany, Entomology.)
Hood, Frazer, Ph. D., Davidson, N. C. (Psychology.)
Hoover, Harvey D., Ph. D., S. T. D., Carthage, Ill.
Hopkins, E. Smith, Ph. D., 706 W. California St., Urbana, Ill. (Inorganic Chemistry.)
Hottes, C. F., Ph. D., University of Illinois, Urbana, Ill. (Botany.)
Houdek, Paul, Rantoul, Ill. (Biology.)
Huey, Walter B., M. D., Elgin, Joliet, and Eastern Ry., Joliet, Ill. (Medicine.)
Hull, Thos. G., Ph. D., State Board of Health, Springfield, Ill. (Health.)
Hunter, Geo. W., Knox College, Galesburg, Ill. (Biology.)
•**Hutton, J. Gladden,** M. S., State College, Brookings, S. D. (Geology.)
Illinois Nature Study Society of Elgin, 310 N. Liberty St., Elgin, Ill.
Illinois State Library, State House, Springfield, Ill.
Isenbarger, Jerome, B. S., 2200 Greenleaf Ave., Chicago, Ill. (Zoology.)
Jane, Wm. T., Room 905, 122 S. Michigan Blvd., Chicago, Ill. (Bausch & Lomb Optical Co.)
Jelliff, Fred R., B. A., Editor, Daily Republican Register, Galesburg, Ill. (Geology.)
Jenks, Ira J., M. S., State Teachers College, DeKalb, Ill. (Chemistry.)
Jensen, Jens, Ravina, Ill. (Geology, Botany.)
Johnson, George F., 625 Black Ave., Springfield, Ill. (Astronomy.)
Johnson, John H., B. Ed., Sup't. of Schools, Tremont, Ill. (Biology.)
Johnson, T. Arthur, M. D., 7th St. and 4th Ave., Rockford, Ill. (Medicine.)
Jones, Elmer E., Ph. D., Northwestern University, Evanston, Ill. (Mental Development, Heredity.)
Jurica, Hilary S., St. Procopius College, Lisle, Ill. (Botany.)
Karpinski, Louis C., Ph. D., 1315 Cambridge Road, Ann Arbor, Mich. (Mathematics.)
Karraker, Edward L., Jonesboro, Ill. (Forestry.)
Kauffman, J. S., M. D., 233 York St., Blue Island, Ill. (Medicine.)
Kempton, F. E., M. S., Bureau of Plant Industry, Dept. of Agriculture, Washington, D. C. (Plant Pathology, Botany.)
Kennicott, Ransom, 547 Cook Co. Bldg., Chicago, Ill. (Forestry.)
Kerr, Charles Roy, M. D., Chenoa, Ill. (Medicine.)
Kibbe, Alice, Carthage, Ill.
King, R. S., 304 W. Bennett St., Pontiac, Ill. (Biology, Chemistry.)
Kirn, George J., M. S., M. A., Ph. D., D. D., Northwestern College, Naperville, Ill. (Psychology, Philosophy.)
Kline, R. G., M. D., Hoopeston, Ill. (Medicine.)
•**Knipp, Charles T.,** Ph. D., University of Illinois, Urbana, Ill. (Physics.)
Knox County Academy of Science, Galesburg, Ill.
Koch, Fred Conrad, Ph. D., 1903 E. 72d St., Chicago, Ill. (Physiological Chemistry.)
Krey, Frank, B. S., State Geological Survey, Urbana, Ill. (Geology.)
Krueger, John H., M. D., 118 Ellinwood St., DesPlaines, Ill. (Medicine.)
Kuderna, J. G., M. S., Normal, Ill. (Physical Science, Education.)
Kudo, Rokusaburo, University of Illinois, Urbana, Ill. (Zoology.)
Kuh, Sidney, M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.)
Kurz, Herman, B. S., Florida State College for Women, Tallahassee, Florida. (Botany.)
Lamar, J. Everts, B. S., State Geological Survey Division, Urbana, Ill. (Geology.)
Lambert, Earl L., B. S., Dakota, Ill. (Botany, Zoology.)
Land, W. J. G., Ph. D., University of Chicago, Chicago, Ill. (Botany.)

Langford, George, B. S., McKenna Process Co., Joliet, Ill. (Paleontology.)
Lanphier, Robert C., Ph. B., Sangamo Electric Co., Springfield, Ill. (Electricity.)
Larson, Karl, B. A., Augustana College, Rock Island, Ill. (Chemistry.)
Lathrop, W. G., Principal Twp. High School, Johnston City, Ill. (Geology, Geography.)
Laves, Kurt, Ph. D., University of Chicago, Chicago, Ill. (Astronomy, Mathematics.)
Lawson, Edwin W., 400 Jefferson Ave., Elgin, Ill.
Lawrence, Nathan A., 6639 S. Lincoln St., Chicago, Ill. (Biology.)
Leighton, Morris Morgan, Ph. D., Chief, Illinois Geological Survey Division, Urbana, Ill. (Geology.)
Lerche, Thorleif I., D. D. S., 3012 E. 92d St., Chicago, Ill. (Medicine.)
Lewis, Howard D., Ph. D., University of Michigan Medical School, Ann Arbor, Mich. (Physiological Chemistry.)
Lewis, Julian H., D. D., Ricketts Laboratory, University of Chicago, Chicago, Ill. (Pathology.)
Linder, O. A., 208 N. Wells St., Chicago, Ill.
Linkins, E. M., M. A., 706 Broadway, Normal, Ill. (Zoology.)
Logsdon, Mrs. M. I., S. B., A. M., Ph. D., University of Chicago, Chicago, Ill. (Mathematics.)
Longden, A. C., Ph. D., Knox College, Galesburg, Ill. (Physics.)
Lukens, Herman T., Ph. D., 330 Webster Ave., Chicago, Ill. (Geography.)
Lutes, Neil, 1595 Atlantic St., Dubuque, Iowa. (Chemistry.)
MacMillan, W. D., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.)
Maddock, Rosa G., B. S., 9648 Vanderpool Ave., Chicago, Ill. (Zoology.)
Madison, Wm. D., M. D., Eureka, Ill. (Medicine.)
Magill, Henry P., 175 W. Jackson Blvd., Chicago, Ill. (Sociology, Finance.)
Malinovsky, A., Chemical Engineer, Washington Iron Works, Los Angeles, California. (Chemistry.)
Mann, A. L., M. D., 392 E. Chicago St., Elgin, Ill. (Medicine.)
Mann, Jessie R., B. S., State Teachers College, DeKalb, Ill. (Biology.)
Marks, Sarah, Pecatonica, Ill. (Biology.)
Martin, Geo. W., B. S., Ph. D., Washington and Jefferson College, Washington, Penn. (Biology.)
Mason, J. Alden, Field Museum, Chicago, Ill. (Anthropology.)
Mason, Arthur J., 5715 Woodlawn Ave., Chicago, Ill.
Mathews, Albert P., Ph. D., University of Cincinnati, College of Medicine, Cincinnati, Ohio. (Biochemistry.)
McAuley, M. Faith, S. M., Home Economics Dept., University of Chicago, Chicago, Ill. (Botany.)
McClure, S. M., McKendree College, Lebanon, Ill.
McCoy, Herbert N., Ph. D., 1623 Hyde Park Blvd., Chicago, Ill. (Chemistry.)
McDougall, W. B., Ph. D., University of Illinois, Urbana, Ill. (Botany.)
McEvoy, S. Aleta, B. S., Rockford High School, Rockford, Ill. (Chemistry.)
McGinnis, Helen A., 6400 S. Maplewood Ave., Chicago, Ill. (Gen. Science.)
McKee, W. A., D. D. S., East Side Square, Benton, Ill. (Dentist.)
McMaster, Archie J., 600 Ravine Ave., Peoria, Ill. (Physics, Chemistry.)
Mecham, John B., Ph. D., 118 S. Center St., Joliet, Ill.
Metcalf, C. S., Ph. D., University of Illinois, Urbana, Ill. (Entomology.)
Metzner, Albertine E., M. S., 24 Marshner St., Plymouth, Wis. (Geology, Physics.)
Michelson, A. A., LL. D., University of Chicago, Chicago, Ill. (Physics.)
Miller, Harry Milton, Jr., Washington University, St. Louis, Mo. (Zoology.)
Miller, Isiah Leslie, M. A., Station A, Box 53, Brookings, South Dakota. (Mathematics, Chemistry.)
Miller, P. K., High School, Henning, Ill. (Biology.)
Miller, R. B., M. F., 223 Natural History Survey, Urbana, Ill. (Forestry, Ecology.)
Milton, Charles, B. A., University of Illinois, Urbana, Ill. (Geology.)
Mitchell, Catherine, A. B., 144 Fairbank Road, Riverside, Ill. (Botany, Ornithology.)
Mongerson, Oscar V., B. S., State Normal University, Normal, Ill. (Physics.)
Montgomery, C. E., M. S., State Teachers College, DeKalb, Ill. (Biology.)
Morgan, Wm. E., M. D., 1016 Hyde Park Blvd., Chicago, Ill. (Medicine.)
Moulton, F. R., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.)
Mullinix, Raymond C., Ph. D., Rockford College, Rockford, Ill. (Chemistry.)
Mumford, H. W., B. S., University of Illinois, Urbana, Ill. (Animal Husbandry, Agriculture.)
Murrah, Frank C., M. D., 105½ N. Park Ave., Herrin, Ill. (Medicine.)

Mylius, L. A., S. B., M. E., 312 N. Neil St., Champaign, Ill. (Geology.)
Nadler, Walter H., M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.)
Neiberger, William E., M. D., Bloomington, Ill. (Eugenics.)
Neifert, Ira E., M. S., 806 E. Knox St., Galesburg, Ill. (Chemistry.)
Nelson, C. Z., 534 Hawkingson Ave., Galesburg, Ill. (Botany.)
Newcomb, Rexford, M. A., University of Illinois, Urbana, Ill. (Engineering Applications.)
Newell, M. J., M. A., 2017 Sherman Ave., Evanston, Ill.
Newman, H. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.)
Nicholson, F. M., 66th St. and Avenue A, New York City. (Anatomy.)
Nirdlinger, Sidney, Ph. D., Galesburg, Ill. (Chemistry.)
Noé, Adolf Carl, University of Chicago, Chicago, Ill. (Botany.)
Normal Science Club, Illinois State Normal University, Normal, Ill. (General.)
North, E. M., B. A., 694 Garland Place, DesPlaines, Ill. (Geology, Astronomy, Pedagogy.)
Obenchain, Jeanette Brown, Ph. B., 6130 Dorchester Ave., Chicago, Ill. (Anatomy.)
Ogilvy, Robert S., 807 Crescent Building., Glen Ellyn, Ill.
Ondrak, Ambrose L., B. A., St. Procopius College, Lisle, Ill. (Physics.)
Ozment, Arel, 806 Washington Ave., Johnston City, Ill. (General.)
Packard, W. H., Ph. D., Bradley Polytechnic Institute, Peoria, Ill. (Biology.)
Paddock, Walter R., M. D., 904 State St., Lockport, Ill. (Medicine.)
Parker, George T., 185 N. Kellogg St., Galesburg, Ill. (Chemistry.)
*Parr, S. W., M. S., University of Illinois, Urbana, Ill. (Chemistry.)
Parson, S. F., State Teachers College, DeKalb, Ill. (Mathematics.)
Patterson, Alice J., Illinois State Normal University, Normal, Ill. (Entomology, Nature Study.)
Patterson, Cecil F., B. S., University of Saskatchewan, Saskatoon, Canada. (Horticulture.)
Patton, Fred P., M. D., Glencoe, Ill. (Medicine.)
Pearsons, H. P., 1816 Chicago Ave., Evanston, Ill.
Peterson, Harvey A., 502 Normal Ave., Normal, Ill.
Phipps, Charles Frank, B. S., M. S., State Teachers College, DeKalb, Ill. (Physics, Chemistry.)
Pieper, Charles J., University of Chicago, Chicago, Ill. (General Science.)
Plapp, F. W., 4140 N. Keeler Ave., Chicago, Ill. (Botany, Geology.)
Platt, Robert S., Ph. D., University of Chicago, Chicago, Ill. (Geography.)
Poling, J. A., M. D., Crum-Forster Bldg., Freeport, Ill. (Medicine.)
Pollock, M. D., M. D., Powers Bldg., Decatur, Ill. (Medicine, Surgery.)
Porter, Charles L., A. B., B. S., 828 N. Main St., W. Lafayette, Ind. (Botany, Plant Pathology.)
Porter, James F., M. A., 1085 Sheridan Road, Hubbard Woods, Ill. (Zoology.)
Quirke, T. T., Ph. D., Room 234 Nat. Hist. Bldg., University of Illinois. Urbana, Ill. (Geology.)
*Radcliffe, H. H., Principal of Night School, 1346 W. Macon St., Decatur, Ill. (Physics, Chemistry.)
Ransom, James H., B. S., James Millikin University, Decatur, Ill. (Chemistry.)
Rauth, Andy Fred, R. F. D. No. 9, Boonville, Ind. (Biology.)
Reagan, Albert B., A. B., A. M., Cornfields, Arizona. (Paleontology, Ethnology, Botany, Geology.)
Redfield, Casper L., 526 Monadnock Block, Chicago, Ill. (Evolution.)
Renich, Mary E., Ph. D., 355 Jefferson St., Galesburg, Ill. (Botany.)
Rew, Irwin, Ph. D., 217 Dempster St., Evanston, Ill.
Rice, Arthur L., M. M. E., 537 S. Dearborn St., Chicago, Ill. (Engineering.)
Richardson, Baxter K., A. B., Dept. of Public Health, Springfield, Ill. (Public Health.)
Richardson, R. E., Ph. D., Vivarium, Cor. Wright and Healy Sts., Champaign, Ill. (Zoology.)
Ridgway, Robert, M. S., 1030 S. Morgan St., Route 7, Olney, Ill. (Ornithology.)
Rinker, Jacob Arron, B. S., Eureka, Ill. (Physics.)
Rockford Nature Study Society, 210 N. Avon St., Rockford, Ill.
Rodebush, W. H., University of Illinois, Urbana, Ill. (Chemistry.)
Romer, A. S., Ph. D., University of Chicago, Chicago, Ill. (Paleontology.)
Root, Clarence J., U. S. Weather Bureau, Springfield, Ill. (Climatology.)
Ruckmick, Christian A., Ph. D., Wellesley College, Wellesley, Mass. (Psychology.)
Rudnick, Paul, 10640 S. Seeley Ave., Chicago, Ill. (Chemistry.)
Salter, Allen, Lena, Ill. (Medicine.)
Sampson, H. C., Ph. D., Ohio State University, Columbus, Ohio.
Savage, T. E., Ph. D., University of Illinois, Urbana, Ill. (Stratigraphic Geology.)
Schantz, Orpheus M., Room 1649, 10 S. LaSalle St., Chicago, Ill. (Birds, Plants.)

Schaub, Edward L., Ph. D., 2437 Sheridan Road, Evanston, Ill. (Psychology.)
Schmidt, Otto L., M. D., 5 So. Wabash Ave., Chicago, Ill. (History.)
Schmoll, Hazel Marguerite, A. B., B. E., M. S., 1437 Pennsylvania Ave. Denver, Colo. (Botany.)
Schneider, Nora, B. S., 403 W. Washington Blvd., Urbana, Ill. (Chemistry.)
Schreiber, Geo F., 80 Illinois St., Chicago Heights, Ill.
Schulz, W. F., Ph. D., University of Illinois, Urbana, Ill. (Physics.)
Scott, R. A., M. S., State Normal University, Carbondale, Ill. (Chemistry.)
Sears, O. H., 606 E. Chalmers St., Champaign, Ill. (Chemistry.)
Shamel, C. H., Ph. D., 802 Massachusetts Ave., N. E., Washington, D. C. (Chemistry.)
Shank, Marjorie M., A. M., 42 W. Walnut St., Carbondale, Ill. (Geography.)
Shelford, V. E., Ph. D., Vivarium Bldg., Wright and Healy Sts., Champaign, Ill. (Zoology, Ecology.)
Shinn, Harold B., 3822 Lowell Ave., Chicago, Ill. (Zoology.)
Shull, Chas. A., Ph. D., University of Chicago, Chicago, Ill. (Botany, Plant Physiology.)
Siedenburg, Frederic, M. A., 1076 West Roosevelt Road, Chicago, Ill. (Sociology.)
Simmons, Marguerite L., B. S., M. A., 325 Melrose Ave., Centralia, Ill. (Biology.)
Simonds, O. C., 1101 Buena Ave., Chicago, Ill. (Botany.)
Simons, Etoile B., Ph. D., 7727 Colfax Ave., Chicago, Ill. (Botany.)
•**Simpson, Q. I.,** Bear Creek Farm, Palmer, Ill. (Eugenics.)
Singer, H. Douglas, M. D., 6625 N. Ashland Ave., Chicago, Ill. (Psychiatry.)
Slaught, H. E., Ph. D., Sc. D., University of Chicago, Chicago, Ill. (Mathematics.)
Slocum, A. W., University of Chicago, Chicago, Ill.
Slye, Maud, A. B., 836 Drexel Ave., Chicago, Ill. (Medicine.)
Smallwood, Mabel E., 550 Surf St., Chicago, Ill. (Zoology.)
Smith, Arthur Bessey, B. S., 2324 Hartzell St., Evanston, Ill. (Telephony.)
•**Smith, C. H.,** M. E., 5517 Cornell Ave., Chicago, Ill. (Physics.)
Smith, Clarence R., B. S., Aurora College, Aurora, Ill. (Physics.)
Smith, Mrs. Eleanor C., B. S., 104 Winston Ave., Joliet, Ill. (Biology.)
Smith, Grant, M. S., 1738 W. 104 St., Chicago, Ill. (Zoology.)
Smith, James W., M. D., Cutler, Perry Co., Ill. (Medicine.)
Smith, Jesse L., Supt. Schools, Highland Park, Ill.
Smith, K. K., Ph. D., Northwestern Univ., Evanston, Ill. (Physics.)
Smith, Merlin G., A. B., A. M., Ph. D., Greenville College, Greenville, Ill. (Mathematics.)
Smith, R. S., Ph. D., 653 Agricultural Bldg., Univ. of Illinois, Urbana, Ill. (Chemistry and Physics of Soils.)
Smith, S. S., Galconda, Pope Co., Ill. (Vocational and Physical Education.)
Snider, Alvin B., M. D., Blue Island, Ill. (Medicine.)
Snider, H. J., B. S., College of Agri., University of Illinois, Urbana, Ill. (Soils, Agri.)
Sonnenschein, Robert, M. D., 4518 Woodlawn Ave., Chicago, Ill. (Medicine.)
Speckman, Wesley N., Ph. D., Elmhurst College, Elmhurst, Ill. (Biology.)
Spicer, C. E., 100 Sherman St., Joliet, Ill. (Chemistry.)
Stark, John Thomas, M. A., 749 Sherman Ave., Evanston, Ill. (Geology.)
Steagall, Mary M., Ph. B., 808 S. Illinois Ave., Carbondale, Ill. (Botany.)
Stevens, F. L., Ph. D., University of Illinois, Urbana, Ill. (Plant Pathology, Botany.)
Stillians, A. W., M. D., 819 East 50th St., Chicago, Ill. (Medicine.)
Stover, E. L., State Teachers College, Charleston, Ill. (Botany.)
Stover, Mrs. E. L., M. S., 930 Second St., Charleston, Ill. (Botany.)
•Strode, W. S., M. D., Lewiston, Ill. (Medicine.)
Strong, Harriet, B. S., 192 E. Maple Ave., Downers Grove, Ill. (Biology.)
Struble, E. H., A. B., 4481 Sheridan Ave., Detroit, Mich. (Physics.)
Swan, W. S., M. D., Cor. Main and Walnut Sts., Harrisburg, Ill. (Medicine.)
Tatum, Arthur L., Ph. D., M. D., University of Chicago, Chicago, Ill. (Physiology, Pharmacology.)
Taylor, Mildred E., A. B., A. M., Knox College, Galesburg, Ill. (Mathematics.)
Tehon, Leo. R., A. B., M. A., Univ. of Illinois, Urbana, Ill. (Botany, Plant Pathology.)
Tharaldsen, C. E., M. A., 719 Emerson St., Evanston, Ill. (Zoology.)
Thomas, E. T., M. A., Haven House, Northwestern University, Evanston, Ill. (Geology.)
Thomas, L. J., 301 Natural History Bldg., University of Illinois, Urbana, Ill.

Thompson, Louis T. E., Ph. D., Naval Proving Station, Dahlgren, Va., (Physics.)
Thompson, O. B., M. D., 201 S. Washington Ave., Carbondale, Ill. (Medicine.)
Thurlimann, Leota, 3856 Gladys Ave., Chicago, Ill. (Botany.)
Thurston, Fredus A., 1361 E. 57th St., Chicago, Ill.
Tiffany, L. Hanford, Ohio State Univ., Columbus, Ohio. (Botany.)
*Townsend, E. J., Ph. D., Univ. of Illinois, Urbana, Ill. (Mathematics.)
Townsend, M. T., B. S., St. John's College, Annapolis, Md. (Animal Ecology.)
Townsley, Fred D., B. A., James Millikin University, Decatur, Ill.
Trapp, A. R., M. D., Illinois National Bank Bldg., Springfield, Ill. (Medical Diagnosis.)
Turton, Chas. M., M. A., 2055 E. 72d Place, Chicago, Ill. (Physics.)
Ulrich, Katherine, Ph. B., 304 N. Oak Park Ave., Oak Park, Ill. (Geology, Geography, Botany.)
Van Cleave, H. J., Ph. D., University of Illinois, Urbana, Ill. (Zoology.)
Van Cleet, Eugene, B. S., Ohio State University, Columbus, Ohio. (Commercial and Econ. Geography, Climatology.)
Van Tuyl, Francis M., Ph. D., Colorado School of Mines, Golden, Colo. (Geology.)
Vestal, A. G., Ph. D., Stanford University, Cal. (Ecology.)
VonKelinski, Walter P., M. D., Ph. D., Station Hospital, Camp Bragg, N. C. (Biology, Physiology.)
Waldo, E. H., E. E., Dept. of Electrical Engineering, University of Illinois, Urbana, Ill. (Electricity.)
Waldo, Jennie E., 1204 Third Ave., Rockford, Ill. (Biology.)
Walker, Ellis David, M. D., B. Sc., Litchfield, Ill. (Pedagogical Med., Biol., Agri.)
Walsh, John, 1120 S. West St., Galesburg, Ill. (Water Supply.)
Wandless, Harold R., Ph. D., 1003 W. Oregon St., Urbana, Ill. (Geology.)
Warbrick, John C., M. D., M. C., 306 E. 43d St., Chicago, Ill. (Birds, Nature Study.)
Ward, Harold B., B. S., Northwestern Univ., Evanston, Ill. (Geology, Geography.)
Waterman, Warren G., Ph. D., Northwestern University, Evanston, Ill. (Botany.)
Watson, F. R., Ph. D., Dept. of Physics, University of Illinois, Urbana, Ill.
Weaver, George H., M. D., 629 S. Wood St., Chicago, Ill. (Medicine, Bacteriology.)
Weaver, H. E., Raymond, Ill.
Weber, H. C. P., Ph. D., Westinghouse Electric Co., Pittsburgh, Pa. (Chemistry.)
Weckel, Ada L., M. S., Twp. High School, Oak Park, Ill. (Zoology.)
Weese, Asa Orrin, James Millikin University, Decatur, Ill.
Weicholt, A., M. D., Barrington, Ill. (Medicine.)
Welker, William H., Ph. D., Univ. of Illinois College of Medicine, 508 S. Honore St., Chicago, Ill. (Biological Chemistry.)
Wells, M. M., Ph. D., General Biological Supply House, 1177 E. 55th St., Chicago, Ill. (Zoology.)
Wentworth, Edward N., B. S., M. S., Armour's Bureau of Agricultural Research and Economics, Chicago, Ill. (Genetics and Economics.)
Wever, Ernest Glen, A. B., 15 Wendell St., Cambridge, Mass. (Biology.)
Whitmore, Frank C., Ph. D., Northwestern University, Evanston, Ill. (Organic Chemistry.)
Whitney, Worallo, A. M., 5743 Dorchester Ave., Chicago, Ill. (Botany.)
Whitten, J. H., Ph. D., 7111 Normal Ave., Chicago, Ill. (Botany.)
Wilczynski, E. J., Ph. D., University of Chicago, Chicago, Ill. (Math.)
Williams, E. G. C., M. D., 316 The Temple, Danville, Ill. (Medicine, Clinical Pathology.)
Willier, Benj. H., Ph. D., Zoology Bldg., University of Chicago, Chicago, Ill. (Zoology.)
Wilson, J. Gordon, M. A., 5755 Kenwood Ave., Chicago, Ill. (Otology.)
Windsor, Mrs. P. L., 701 Michigan Ave., Urbana, Ill. (Entomology.)
*Winter, S. G., M. A., Lombard College, Galesburg, Ill. (Histology.)
Witt, Dr. J. C., 881 Cordelia Ave., Chicago, Ill. (Chemistry.)
Witzemann, Edgar J., Ph. D., 321 S. Ridgeland Ave., Oak Park, Ill. (Chemistry.)
Wolkoff, M. I., Ph. D., Agricultural Experiment Station, Urbana, Ill. (Soil Fertility.)
Wood, F. E., 804 N. Evans St., Bloomington, Ill. (Biology.)
Woodruff, Frank M., Chicago Academy of Science, Chicago, Ill. (Taxidermy.)
Woods, F. C., 100 N. Cherry St., Galesburg, Ill. (Physics.)
Worsham, Walter B., A. B., Paris, Ill. (Physics.)
Wright, Frank, M. D., 5 S. Wabash Ave., Chicago, Ill. (Biological Chemistry.)
Wright, Paul R., B. A., Michigan Ave. and Oak St., Highland Park, Ill. (Geology.)

Wynne, Ross B., A. B., 250 E. 111th St., Chicago, Ill. (Botany.)
Young, Mrs. J. D., M. S., Windermere Hotel, 56th St. and Cornell Ave., Chicago, Ill. (Zoology.)
Young, Paul Allen, A. B., 204 Vivarium Bldg., University of Illinois, Urbana, Ill. (Botany.)
Zehren, Karl C., Flanigan, Ill. (Agriculture.)
*Zetek, James, A. M., Box 245, Ancon, Panama Canal Zone. (Entomology.)
Zimmerman, Augustine G., 30 N. Michigan Ave., Chicago, Ill. (Biological Science.)
Zoller, C. H., M. D., Hughes Bldg., Litchfield, Ill. (Medicine.)

SCIENTIFIC SOCIETIES AFFILIATED WITH THE ACADEMY.

Illinois Nature Study Society of Elgin, 310 N. Liberty St., Elgin, Illinois.
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